

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

Apple Inc.
“Apple”
Petitioner

v.

Advanced Coding Technologies, LLC
“ACT”
Patent Owner

INTER PARTES REVIEW OF U.S. PATENT NO. 9,042,448

DECLARATION OF MR. DAVID B. LETT

I declare that all statements made in this declaration on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: 6/2/2025

By: David B. Lett

David B. Lett

Contents

I.	Introduction.....	4
II.	Materials Considered.....	4
III.	Qualifications.....	11
	A. Summary	11
IV.	Legal Standards	17
V.	Overview of the '448 Patent.....	19
	A. Technical Background.....	19
	B. Brief Description	21
	C. Examination History.....	29
VI.	Person of Ordinary Skill in the Art.....	30
VII.	Claim Construction.....	31
VIII.	Ground 1A – Obviousness based on Phek-Segall-He	31
	A. Overview of Phek.....	31
	B. Overview of Segall.....	32
	C. Overview of He	34
	D. Combination of Phek, Segall, and He	36
	E. Analysis	60
IX.	Ground 1B – Obviousness based on Phek-Segall-He-Takahashi	65
	A. Overview of Takahashi	65
	B. Combination of Phek, Segall, He, and Takahashi.....	68
	C. Analysis	71
X.	Ground 1C – Obviousness based on Phek-Segall-Takahashi	71

XI.	Ground 1D – Obviousness based on Phek-Takahashi.....	72
XII.	Additional Remarks	73

I, David B. Lett, do hereby declare:

I. Introduction

1. My name is David Lett, and I have been retained by counsel for Apple Inc. (“Apple”) as an expert witness to assist in analyzing issues related to the patentability of certain claims of U.S. Patent No. 9,042,448, “the ’448 Patent.” I understand that Apple intends to submit this declaration in support of a petition for *inter partes* review (“IPR”) of the ’448 Patent before the Patent Trial and Appeal Board (“PTAB”) of the United States Patent and Trademark Office (“USPTO”).

2. I am being compensated for my work in this matter at my standard hourly rate. My compensation in no way depends on the outcome of this proceeding or the content of my testimony.

3. My analysis here is based on my years of education, research and experience, as well as my investigation and study of relevant materials, including those cited herein. I may rely upon these materials, my knowledge and experience, and/or additional materials to further explain and corroborate my analysis, and to respond to any critiques of my analysis that may be raised during the course of the IPR proceeding in which this declaration is submitted.

II. Materials Considered

4. I have reviewed the IPR Petition that Apple is submitting to the PTAB to challenge claims 1-3 of the ’448 Patent. In fact, in preparing this declaration, I

collaborated with counsel in developing the obviousness grounds set forth in the Petition. Based on my review, the Petition accurately portrays my opinions regarding the patentability of claims 1-3 of the '448 Patent. I fully endorse the obviousness grounds, including the proposed combinations and mapping of those prior art combinations to the elements of claims 1-3 as described in the Petition.

5. I also understand that an earlier IPR proceeding, IPR2024-00372, was instituted at the PTAB involving related U.S. Patent No. 10, 218, 995 (the '995 Patent), in which Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (collectively, "Samsung") were the petitioners (the "Samsung IPR"). Dr. Clifford Reader submitted a declaration in the Samsung IPR that included an overview of the state of the art and an introduction to the technology described and claimed in the '995 Patent. Because the '995 and '448 Patents share an identical specification and claim related subject matter, Dr. Reader's discussion is similarly relevant here and provides helpful context for understanding the technology described and claimed in the '448 Patent. Rather than repeat similar content here, I refer to Dr. Reader's discussion at Sections II and V of his '995 declaration from the Samsung IPR—submitted in this proceeding as exhibit APPLE-1078—for background information on the technology and state of the art of the '448 Patent.

6. In addition to the Petition and Sections II and V of Dr. Reader's declaration from the Samsung IPR, I reviewed the following additional material in the course of preparing this declaration on the '448 Patent:

APPLE-1001	U.S. Patent No. 9,042,448 to Sakazume ("the '448 Patent")
APPLE-1002	Excerpts from the Prosecution History of the '448 Patent ("the '448 Patent File History")
APPLE-1005	English Translation of Japanese Patent Publication No. 2007316161 A with Translation Certificate ("Phek")
APPLE-1006	Segall et al., <i>Spatial Scalability Within the H.264/AVC Scalable Video Coding Extension</i> ; IEEE Transactions on Circuits & Systems for Video Tech., Vol. 17, No. 9, September 2007 ("Segall")
APPLE-1007	Martins et al., <i>A Unified Approach to Restoration, Deinterlacing and Resolution Enhancement in Decoding MPEG-2 Video</i> , IEEE Transactions on Circuits & Systems for Video Tech., Vol. 12, No. 9, September 2002 ("Martins")
APPLE-1008	U.S. Patent Publication No.2008/0137753 ("He")
APPLE-1009	U.S. Patent No. 5,886,736 ("Chen")
APPLE-1010	Schwarz et al., <i>Overview of the Scalable Video Coding Extension of the H.264/AVC Standard</i> , IEEE Transactions on Circuits & Systems for Video Tech., Vol. 17, No. 9, September 2007 ("Schwarz")
APPLE-1011	U.S. Patent Publication No. 2009/0154567 ("Lei")
APPLE-1012	Park et al., <i>SuperResolution Image Reconstruction: A Technical Overview</i> , IEEE Signal Processing Magazine, pp. 21-36, May 2003 ("Park")
APPLE-1013	English Machine Translation of Japanese Patent Publication No. 2008053848 ("Hatanaka")

APPLE-1014	U.S. Patent Publication No. 2010/0165077 (“Yin”)
APPLE-1015	U.S. Patent Publication No. 2009/0257664 (“Kao”)
APPLE-1016	U.S. Patent Publication No. 2009/0046995 (“K anumuri”)
APPLE-1017	U.S. Pat. 6,470,051 (“Campisano”)
APPLE-1018	U.S. Patent Publication No. 2006/0013306 (“Kim”)
APPLE-1019	Lu et al., Mechanisms of MPEG Stream Synchronization, ACG SIGCOMM Computer Communication Review, Vol. 24, Issue 1, pp. 57-67 (January 1994) (“Lu”)
APPLE-1020	U.S. Patent Publication No. 2003/0021345 (“Brusewitz”)
APPLE-1021	U.S. Patent Publication No. 2003/0021347 (“Lan”)
APPLE-1022	EE Times, <i>How Video Compression Works</i> (Aug. 6, 2007), available at https://www.eetimes.com/how-video-compression-works (retrieved Dec. 26, 2023) (“EETimes”)
APPLE-1023	Bier, <i>Introduction to Video Compression</i> , Berkeley Design Tech., Inc. (October 2005), available at https://www.bdti.com/MyBDTI/pubs/20051024_GSPx05_Video_Intro.pdf (retrieved Dec. 30, 2023) (“Bier”)
APPLE-1024	U.S. Patent No. 7,379,496 (“Holcomb”)
APPLE-1025	U.S. Patent Publication No. 2008/0043832 (“Barkley”)
APPLE-1026	U.S. Patent No. 6,173,013 (“Suzuki”)
APPLE-1030	Ely, <i>MPEG Video Coding: A Simple Introduction</i> , EBU Technical Review (Winter 1995) (“Ely”)
APPLE-1031	Japanese Patent Publication No. 2007316161 A with English Machine Translation (“Phek”)
APPLE-1032	ITU-T Recommendation H.264 (11/07)

APPLE-1033	Karczewicz et al., The SP- and SI-Frames Design for H.264/AVC, IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, v.13 (July 2003)
APPLE-1034	ISO/IEC 11172-2: 1993 (E) (MPEG1 Video)
APPLE-1035	ISO/IEC 13818-2: 2000 (E) (MPEG2/H.262 Video)
APPLE-1036	ITU-T Recommendation H.263 (02/98)
APPLE-1037	Reader, Intraframe and Interframe Adaptive Transform Coding, Efficient Transmission of Pictorial Information, SPIE v.66, 108 (1975)
APPLE-1038	Reader, MPEG4: Coding for Content, Interactivity, and Universal Accessibility, Optical Engineering 35(1), 104 (January 1996)
APPLE-1039	Reader, MPEG Patents, in MPEG Video Compression Standard, Chapter 16, at 357-362 (Mitchell et al ed.) (1996)
APPLE-1040	Radha et al., The MPEG-4 Fine-Grained Scalable Video Coding Method for Multimedia Streaming Over IP, IEEE Transactions on Multimedia, v.3, 53 (March 2001)
APPLE-1041	H.264 / MPEG-4 Part 10 White Paper, January 31, 2003 (downloaded from https://github.com/yistLin/H264-Encoder/blob/1cdaf090b63642932ed726b102ed2cf80908edbb/doc/H.264%20%3A%20MPEG-4%20Part%2010%20White%20Paper.pdf on Jan. 5, 2024)
APPLE-1042	ISO/IEC 14496-2: 2004 (MPEG4)
APPLE-1043	ISO/IEC 13818-2: 1996 (MPEG2)
APPLE-1046	U.S. Patent Publication No. 2001/0043751 (“Takahashi”)
APPLE-1047	Peter J. Burt et at., <i>The Laplacian Pyramid as a Compact Image Code</i> , IEEE TRANSACTIONS ON COMMUNICATIONS, VOL. COM-31, NO. 4, APRIL 1983 (“Burt”)

- APPLE-1048 Michael Elad et al., *Restoration of a Single Superresolution Image from Several Blurred, Noisy, and Undersampled Measured Images*, IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 6, NO. 12, DECEMBER 1997 (“Elad”)
- APPLE-1049 Michal Irani et al., *Super resolution from image sequences*, [1990] Proceedings. 10th International Conference on Pattern Recognition, Atlantic City, NJ, USA, 1990, pp. 115-120 vol.2, doi: 10.1109/ICPR.1990.119340 (“Irani”)
- APPLE-1050 U.S. Patent Publication No. 2007/0160133 (“Bao”)
- APPLE-1051 U.S. Patent Publication No. 2004/0170330 (“Fogg”)
- APPLE-1052 U.S. Patent Publication No. 2006/0126952 (“Suzuki952”)
- APPLE-1053 U.S. Patent Publication No. 2004/0022318 (“Garrido”)
- APPLE-1054 U.S. Patent Publication No. 2005/0019000 (“Lim”)
- APPLE-1055 U.S. Patent Publication No. 2004/0156561 (“Yu-Chuan”)
- APPLE-1056 U.S. Patent Publication No. 2008/0018506 (“Raveendran”)
- APPLE-1057 Hunt B R, *Super-Resolution of Images- Algorithms, Principles, Performance*, Intl. Jnl. of Imaging Sys. and Technol., Vol. 6, pp. 297-304, Wiley, 1995, Oct. 1995 (“Hunt_Oct_1995”)
- APPLE-1058 Kramer P, O. Hadar, Benois-Pineau J, Domenger J-P, *Use of Motion Information in Super-Resolution Mosaicing*, ICIP, Oct. 2006 (“Kramer”)
- APPLE-1059 Patti A J, Sezan M I, Tekalp M, *Superresolution video reconstruction with arbitrary sampling lattices and nonzero aperture time*, IEEE Trans. on Im. Proc., Vol. 6, No. 8, pp. 10 (“Patti”)
- APPLE-1060 Erickson K J, Schultz R R, *MPEG-1 super-resolution decoding for the analysis of video still images*, 4th IEEE Southwest Symp. on Im. Anal. and Interp., Apr. 2000 (“Erickson”)

APPLE-1061	Tsai R Y, Huang T S, <i>Multiframe image restoration and registration, Advances in Computer Vision and Image Processing</i> , Vol. 1, T. S. Huang, ed., Jai Press, pp. 317-319, 1984 (“Tsai”)
APPLE-1062	WIPO Patent Publication No. WO2008/057308A2 (“Kao308”)
APPLE-1063	U.S. Patent No. 5,606,369 (“Keesman”)
APPLE-1064	U.S. Patent Publication No. 2007/0201560 (“Segall560”)
APPLE-1065	U.S. Patent Publication No. 2004/0022518 (“Taga”)
APPLE-1066	U.S. Patent No. 6,510,177 (“DeBonet”)
APPLE-1067	U.S. Patent No. 6,023,535 (“Aoki”)
APPLE-1068	U.S. Patent Publication No. 2007/0160153 (“Sullivan”)
APPLE-1069	U.S. Patent Publication No. 2006/0222079 (“Park079”)
APPLE-1070	Exhibit SAMSUNG-1006 as submitted in IPR2024-00327
APPLE-1071	Exhibit SAMSUNG-1007 as submitted in IPR2024-00327
APPLE-1072	Exhibit SAMSUNG-1010 as submitted in IPR2024-00327
APPLE-1073	JP2009182776A and English Machine Translation (“Kuroda”)
APPLE-1074	U.S. Patent No. 8,023,561 (“Garrido561”)
APPLE-1075	U.S. Patent No. 6,580,754 (“Wan”)
APPLE-1076	U.S. Patent No. 5,408,270 (“Lim270”)
APPLE-1077	EP 1811786 (“Wang”)
APPLE-1078	Declaration of Dr. Clifford Reader from IPR2024-00372

III. Qualifications

A. Summary

7. I am a technical consultant and product development industry veteran with expertise in electronics, software, hardware, video, audio, and data communications (including wireless cellular and Bluetooth), having led product development organizations in cable, satellite, consumer electronics, asset tracking, remote tank logistics, and alarm industries. My current *curriculum vitae* is attached as Appendix A and some highlights follow.

8. I earned my B.S. in Electrical Engineering (1982) with high honors from the University of Tennessee in Knoxville, Tennessee. I also attended the Georgia Institute of Technology from 1986 to 1987, completing 40% of the required degree hours for the M.S. Electrical Engineering program.

9. From 1982 to 1985, I worked at Scientific Atlanta as an Electrical Engineer designing video, audio, and data communications equipment for the cable television industry. I designed software and hardware including addressable data transmitters, video sync suppression scramblers, transaction format converters, and data channel monitors for addressable Cable Television systems and Set Top Boxes.

10. From 1983 to 1985, while working at Scientific Atlanta, I also worked as an Assistant Professor at DeVry Institute of Technology, teaching courses in electronics and microprocessor hardware/software.

11. From 1985 to 1990, I worked at Wegener Communications as a Senior Electrical engineer, designing satellite communications equipment including forward error correction (FEC) coding systems, PSK modems, and analog control systems for RF modulators and PSK demodulators. I was promoted to the Hardware Engineering Manager, where I managed product development of video, audio, and data satellite receivers, modulators, graphics display systems, DSP-based companders, FSK and PSK satellite modems, multiplexers, forward error correction (FEC) codecs, RF upconverters and downconverters, and baseband analog and digital processing components.

12. In 1990, I returned to Scientific Atlanta, which was acquired by Cisco in 2006. I worked as Engineering Manager running the set top box engineering group where I was promoted to Director and Vice President during my tenure until 2011. I led the design of many cable set top boxes and systems through the evolution of analog video, addressability, downloadable software, electronic program guides, digital video, software applications, high-definition TV, DVR, DOCSIS, full spectrum tuners, and multiroom DVR. These systems implemented various technologies including DOCSIS 1/2/3 and hybrid gateways, 802.11, IPTV, DVR, cable modems, ADSL, VDSL, DVB-T/C/S, bootloaders, factory diagnostics, application frameworks, Nagra, DRMs, conditional access, secure microprocessors, device management, Android, Adobe Flash, Linux, DVD play/record, MPEG-4,

MPEG-2, H.264, NTSC, PAL, DAVIC, MoCA, high-performance CPUs, cablecards, network processors, HDMI, multiple video/audio display interfaces, 2D/3D graphics, and multiple RF tuners.

13. From 2011 to 2016, I worked for EchoStar Technologies, which served as the product development organization for sister company DISH Network. I served as Vice President of Engineering and was the Head of the Atlanta research and development center. I led the development of satellite set top boxes, consumer electronic equipment, and a home automation and security system. Technologies used included video/audio, IoT, H.265, HEVC, 3D, Satellite, wireless Zigbee, Z-Wave, Wi-Fi, Bluetooth, MoCA, transcoding, embedded C Linux applications, mobile applications (IOS and Android), SaaS, web applications (Javascript, HTML), BSS/OSS, AWS cloud storage, 2-way video/audio streaming, authentication, and VoIP.

14. In 2016, I started an independent consulting business in technology and intellectual property projects. I have consulted in various technology areas and industries including consumer electronics, cable, satellite, television, video/audio/image processing, multimedia content, networking, security, camera, online advertising, and Internet of Things (IoT).

15. From 2019 to 2022, I worked as Chief Technology Officer for Telular, an Ametek company. I was responsible for the development of Industrial IoT (IIoT)

recurring revenue solutions, combining wireless technologies (cellular, Bluetooth, sub-GHz, GPS, and satellite), purpose-built hardware, and SaaS in the commercial telematics, security and home automation markets and sold under the SkyBitz and Telguard Brands.

16. My record of professional service includes awards on products I designed and developed from several organizations in my field of expertise, including Best of Show, Technology Emmy, and Best of Innovations.

17. I am a named inventor on at least 118 issued patents and published patent applications corresponding to the areas of my professional work. The patents and published applications involving video and audio technologies include:

- U.S. Patent No. 9,615,139 titled “Determining Device That Performs Processing of Output Pictures”
- U.S. Patent No. 9,495,860 titled “False Alarm Identification”
- U.S. Patent No. 9,882,736 titled “Remote Sound Generation for a Home Automation System”
- European Patent No. EP 1,552,698 titled “Video transmission systems and methods for a home network”
- U.S. Patent Nos. 8,120,924, 7,240,217, 6,785,817, 6,564,324, 6,212,278 and 5,440,632 titled “Reprogrammable subscriber terminal”

- U.S. Patent Application No. US2015/0160635 titled “Multi-Tiered Feedback-Controlled Home Automation Notifications”
- U.S. Patent Application Publication No. 2015/0161882 titled “False alarm identification”
- U.S. Patent No. 8,549,567 titled “Media Content Sharing Over a Home Network”
- U.S. Patent Nos. 9,247,409 and 9,691,261 titled “Home Automation Communications”
- U.S. Patent No. 5,657,414 titled “Auxiliary device control for a subscriber terminal”
- PCT Patent Publication No. WO 2003/083606 titled “Exporting data from a digital home communication terminal to a client device”
- U.S. Patent No. 5,592,551 titled “Method and apparatus for providing interactive electronic programming guide”
- U.S. Patent No. 8,161,388 titled “Interactive discovery of display device characteristics”
- U.S. Patent No. 7,908,625 titled “Networked Multimedia System”
- U.S. Patent Nos. 7,861,272 and 7,849,486 titled “Networked subscriber television distribution”

- U.S. Patent Nos. 7,774,820 and 7,069,578 titled “Settop cable television control device and method including bootloader software and code version table for maintaining and updating settop receiver operating system software”
- U.S. Patent No. 5,715,515 titled “Method and apparatus for downloading on-screen graphics and captions to a television terminal”
- U.S. Patent No. 5,539,822 titled “System and Method for Subscriber Interactivity in a Television System”
- U.S. Patent Application Publication Nos. 2004/0068753 and 2008/0072272 titled “Video Transmission Systems and Methods for a Home Network”
- U.S. Patent No. 5,771,064 titled “Home communications terminal having an applications module”
- U.S. Patent Application Publication No. 2004/0133911 titled “Subscriber Network in a Satellite System”
- U.S. Patent No. 5,367,571 titled “Subscriber terminal with plug in expansion card”
- U.S. Patent No. 5,357,276 titled “Method of Providing Video On Demand with VCR Like Functions”

IV. Legal Standards

18. I have been asked to provide my opinions as to whether claims 1-3 of the '448 Patent would have been obvious to a person of ordinary skill in the art as of the earliest claimed priority date of the '448 patent (May 30, 2008) ("Critical Date").

19. I am an engineer by training and profession. The opinions I express in this declaration involve the application of my technical knowledge and experience to the evaluation of certain prior art with respect to the '448 Patent. In addition, I understand that the following legal principles apply.

20. It is my understanding that, in determining whether claims of the '448 patent are obvious in this proceeding, the claim terms are generally given their ordinary and customary meaning as understood by a person of ordinary skill in the relevant art. A person of ordinary skill in the art would read the claim terms in the context of the entire patent specification in which they appear, as well as the prosecution history of the patent.

21. It is my understanding that a claim is unpatentable under 35 U.S.C. § 103 if the claimed subject matter as a whole would have been obvious to a person of ordinary skill in the art at the time of the alleged invention. I also understand that an obviousness analysis takes into account the scope and content of the prior

art, the differences between the claimed subject matter and the prior art, and the level of ordinary skill in the art at the time of the invention.

22. In determining the scope and content of the prior art, it is my understanding that a reference is considered relevant prior art if it falls within the field of the inventor's endeavor. In addition, a reference is prior art if it is reasonably pertinent to the particular problem with which the inventor was involved. A reference is reasonably pertinent if it logically would have commended itself to an inventor's attention in considering his problem. If a reference relates to the same problem as the claimed invention, that supports use of the reference as prior art in an obviousness analysis.

23. To assess the differences between prior art and the claimed subject matter, it is my understanding that 35 U.S.C. § 103 requires the claimed invention to be considered as a whole. This "as a whole" assessment involves showing that one of ordinary skill in the art at the time of invention, confronted by the same problems as the inventor and with no knowledge of the claimed invention, would have selected the elements from the prior art and combined them in the claimed manner.

24. It is my further understanding that several rationales may be applied for combining references or modifying a reference to show obviousness of claimed subject matter. These rationales include: combining prior art elements according to

known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions; applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify a prior art reference or to combine prior art teachings to arrive at the claimed invention.

V. Overview of the '448 Patent

A. Technical Background

25. The '448 Patent relates to video coding technology, including the use of “super-resolution” techniques to enhance pictures in a video coding system.

26. The '448 Patent discloses a predictable collection of conventional video coding features that were well known to a POSITA before the Critical Date. These features include:

(i) **motion-compensated coding** in which pictures (or regions of pictures) in a video stream are compressed by using a previously decoded picture (or a region of the previously decoded picture)—referred to as a “reference picture”—to predict other picture(s) (or region(s) of the other picture(s)) in the video stream;

(ii) **loop filtering** in which the previously decoded pictures—i.e., “reference pictures”—are enhanced before being used to predict other picture(s);

(iii) **super-resolution processing** in which multiple lower resolution pictures of the same scene are registered and used to form a super-resolution picture of the scene that has both higher information content (e.g., more detail) than any of the individual lower-resolution input pictures and a higher spatial resolution (e.g., higher pixel count¹) than the input pictures; and

(iv) **layered, hierarchical coding** in which two or more related video streams are encoded together to provide a base layer that can be decoded

¹ The '448 Patent sometimes uses the term “resolution” to refer to the amount of detail (e.g., information content) in a picture and at other times uses the term “resolution” to refer to the size (e.g., number of pixels) in the picture. The meaning is context dependent. *Id.*

independent of the other layers and one or more enhancement layers that are decoded in dependence on the base layer.²

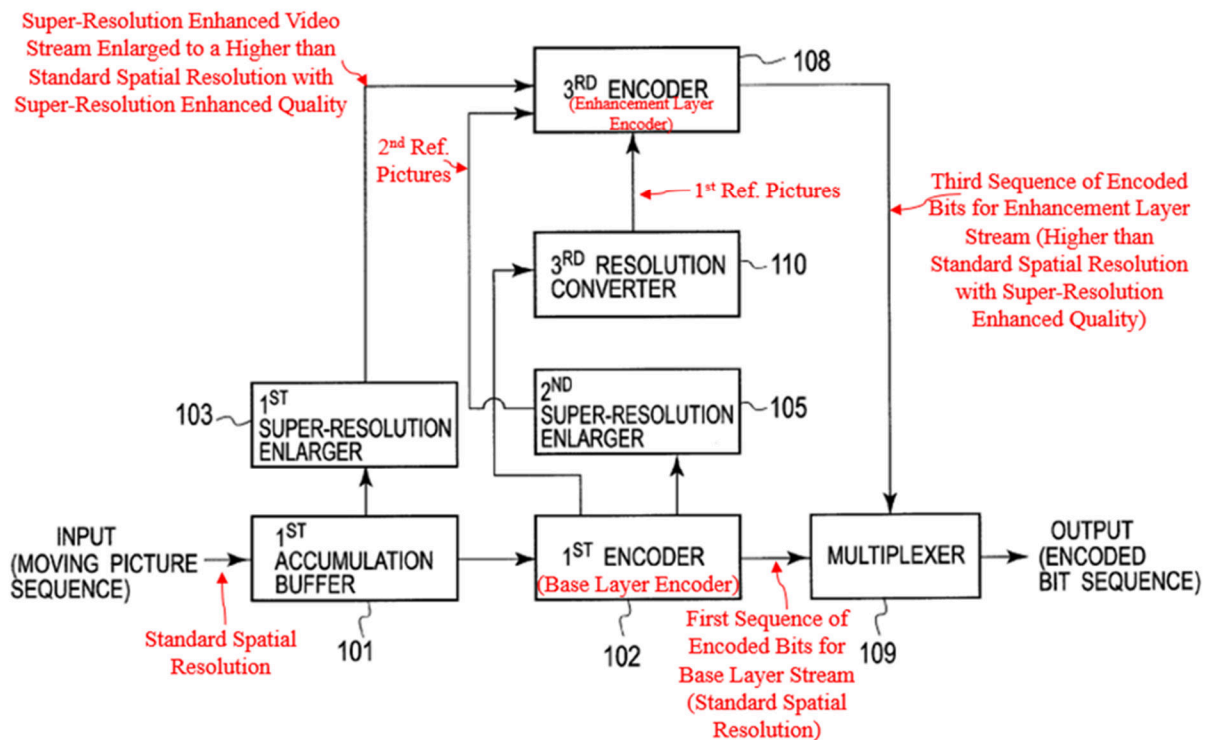
27. For additional information on these and related video coding concepts, and the state of the art as of the Critical Date of the '448 Patent, I refer to Sections II and V of Dr. Reader's declaration from the Samsung IPR on the related '995 Patent that addresses these concepts in further detail.

B. Brief Description

28. The '448 Patent describes layered or hierarchical video coding systems that apply conventional super-resolution techniques to enhance both (i) an original video stream that is provided as input to a video encoding/compression process and (ii) reference pictures used in a process for predicting pictures in the super-resolution enhanced video stream. FIG. 13's depiction of an encoding apparatus is instructive:

² Common forms of layered, hierarchical coding include multi-view coding (e.g., for stereoscopic video) and scalable coding for transmission of multiple streams differentiated by signal-to-noise ratio, frame rate, and/or spatial resolution.

FIG. 13



APPLE-1001, FIG. 13 (annotated)

29. As shown above, the encoding apparatus passes pictures from the input video sequence through an accumulation buffer 101 to each of two encoding paths. APPLE-1001, 33:60-34:4. In the first path, the original, base version of the input video having a standard spatial resolution is encoded by the first encoder 102 to produce a first coded bitstream for the base version of the video at the standard spatial resolution. Id., 37:22-29. The first encoder 102 is also operable to decode the base version of the encoded input video at the standard resolution. Id., 37:30-31. The set of decoded pictures with the standard resolution are provided from the first encoder 102 to the second super-resolution enlarger 105 and the third

resolution converter 110, each of which operates on the set of decoded pictures with the standard resolution to generate a respective set of reference pictures with a resolution higher than the standard resolution. *Id.*, 37:36-52.

30. In the second path, a set of encoding target pictures are created by processing the pictures from the input video through a first super-resolution enlarger 103. APPLE-1001, 34:46-61. The first super-resolution enlarger 103 applies the same or similar super-resolution processing techniques as the second super-resolution enlarger 105 to enhance the spatial resolution and information content (e.g., quality) of the pictures from the original input video sequence. *Id.*, 34:13-18. For each input video picture that is to be subjected to super-resolution processing, the first accumulation buffer 101 accumulates subsequences of pictures from the neighborhood of the input video picture that is to be super-resolution enhanced, in which the pictures in the subsequences are registered with sub-pixel accuracy to provide a corresponding super-resolution image. *Id.*, 33:57-40:64; *see also id.*, 4:27-42, 33:57-40:64. These super-resolution enlarged input pictures are provided to the third encoder 108 as encoding target pictures. *Id.*

31. As noted above, the encoding apparatus processes the set of decoded pictures with the standard resolution from the first encoder 102 in at least two ways. The second super-resolution enlarger 105 processes the set of decoded pictures with the standard resolution to create super-resolution enlarged decoded pictures with a

resolution higher than the standard resolution. APPLE-1001, 33:57-40:64. The third resolution converter 110 processes the same set of decoded pictures with the standard resolution using conventional resolution conversion (rather than super-resolution techniques) to create resolution-converted enlarged decoded pictures with a resolution matching that of the super-resolution enlarged pictures. *Id.*

32. The third encoder 108³ receives three inputs: (1) super-resolution enlarged pictures from the first super-resolution enlarger 103 as encoding target pictures, (2) resolution-converted enlarged decoded pictures from the third resolution converter 110 as first reference pictures, and (3) super-resolution enlarged decoded pictures from the second super-resolution enlarger 105 as second reference pictures. APPLE-1001, 34:46-61. The third encoder 108 implements a combination of processes for prediction and encoding to create a third sequence of encoded bits representing an encoded/compressed version of the super-resolution

³ The embodiment depicted in FIG. 13 includes a first encoder 102 and a third encoder 108. The '448 Patent also describes a second encoder 107, although the second encoder 107 not provided in the embodiment depicted in FIG. 13. *See, e.g.,* APPLE-1001, FIG. 1. The claims of the '448 Patent likewise recite limitations directed to a “first encoder” and a “third encoder,” but the claims do not further require an additional “second encoder.” APPLE-1001, Claims 1-3.

enlarged pictures from the first super-resolution enlarger 103. *Id.* Further, the third encoder 108 makes a selection of reference picture for each picture or for each set of a prescribed number of pictures. *Id.*, 35:6-14 . The third encoder 108 may be configured to create a set of data on the selection of reference picture to identify a first reference picture or a second reference picture whichever is used. *Id.* Finally, the multiplexer 109 combines the first sequence of encoded bits from the first encoder 102 and the third sequence of encoded bits from the third encoder 108 into a single output signal. *Id.*, 36:13-44.

33. The configuration of the encoding apparatus depicted in FIG. 13 permits encoding of higher-resolution content while still maintaining the base layer encoding for compatibility with standard resolution decoders. APPLE-1001, 33:57-41:22, FIGs. 13 and 15. By providing both super-resolution enlarged reference pictures and conventionally upsampled reference pictures to the third encoder, the system allows for flexible reference picture selection to optimize coding efficiency at the higher resolution. *Id.*

34. For reference, I provide the following listing of challenged claim elements from the '448 Patent:

Claim 2	
[1.P]	A moving picture encoding system that makes an encoding of a sequence of moving pictures with a resolution higher than a standard resolution using moving pictures contents which include a sequence of moving pictures with the standard resolution and do not

	include a sequence of moving pictures with a resolution higher than the standard resolution, the moving picture encoding system comprising:
[1.1]	a first encoder configured to work on a sequence of moving pictures with a standard resolution to implement a first combination of processes for an encoding and a decoding to create a first sequence of encoded bits and a set of decoded pictures with the standard resolution;
[1.2]	a first super-resolution enlarger configured to work on the sequence of moving pictures with the standard resolution to implement a process for a first super-resolution enlargement to create a set of super-resolution enlarged pictures with a resolution higher than the standard resolution;
[1.3]	a second super-resolution enlarger configured to acquire the set of decoded pictures from the first encoder to implement thereon a process for a second super-resolution enlargement to create a set of super-resolution enlarged decoded pictures with a resolution higher than the standard resolution;
[1.4]	a third resolution converter configured to acquire the set of decoded pictures from the first encoder to implement thereon a process for a third resolution conversion to create a set of resolution converted enlarged decoded pictures with a resolution higher than the standard resolution; and
[1.5]	a third encoder configured to have the set of super-resolution enlarged pictures from the first super-resolution enlarger as a set of encoding target pictures, employing the set of super-resolution enlarged decoded pictures from the second super-resolution enlarger and the set of resolution converted enlarged decoded pictures from the third resolution converter as sets of reference pictures, to implement thereon a third combination of processes for a prediction and an encoding to create a third sequence of encoded bits,
[1.6]	wherein a spatial resolution of the set of super-resolution enlarged pictures, that of the set of super-resolution enlarged decoded pictures, and that of the set of resolution converted enlarged decoded pictures are made equal; and
[1.7]	wherein the third encoder controls a selection of a set of reference pictures and creates a set of data on the selection of the set of reference pictures to identify a selected set of reference pictures during the process for prediction of the third combination.

Claim 2	
[2.P]	A moving picture encoding system that makes an encoding of a sequence of moving pictures with a resolution higher than a standard resolution using moving pictures contents which include a sequence of moving pictures with the standard resolution and do not include a sequence of moving pictures with a resolution higher than the standard resolution, the moving picture encoding system comprising:
[2.1]	a first encoder configured to work on a sequence of moving pictures with a standard resolution to implement a first combination of processes for an encoding and a decoding to create a first sequence of encoded bits and a set of decoded pictures with the standard resolution;
[2.2]	a first super-resolution enlarger configured to work on the sequence of moving pictures with the standard resolution to implement a process for a first super-resolution enlargement to create a set of super-resolution enlarged pictures with a resolution higher than the standard resolution;
[2.3]	a third resolution converter configured to acquire the set of decoded pictures from the first encoder to implement thereon a process for a third resolution conversion to create a set of resolution converted enlarged decoded pictures with a resolution higher than the standard resolution; and
[2.4]	a third encoder configured to have the set of super-resolution enlarged pictures from the first super-resolution enlarger as a set of encoding target pictures, employing the set of resolution converted enlarged decoded pictures from the third resolution converter as a set of reference pictures, to implement thereon a third combination of processes for a prediction and an encoding to create a third sequence of encoded bits,
[2.5]	wherein a spatial resolution of the set of super-resolution enlarged pictures, and that of the set of resolution converted enlarged decoded pictures are made equal; and
[2.6]	wherein the third encoder controls a selection of a set of reference pictures and creates a set of data on the selection of the set of reference pictures to identify a selected set of reference pictures during the process for prediction of the third combination.
Claim 3	

[3.P]	A moving picture encoding system that makes an encoding of a sequence of moving pictures with a resolution higher than a standard resolution using moving pictures contents which include a sequence of moving pictures with the standard resolution and do not include a sequence of moving pictures with a resolution higher than the standard resolution, the moving picture encoding system comprising:
[3.1]	a first encoder configured to work on a sequence of moving pictures with a standard resolution to implement a first combination of processes for an encoding and a decoding to create a first sequence of encoded bits and a set of decoded pictures with the standard resolution;
[3.2]	a first super-resolution enlarger configured to work on the sequence of moving pictures with the standard resolution to implement a process for a first super-resolution enlargement to create a set of super-resolution enlarged pictures with a resolution higher than the standard resolution;
[3.3]	a second super-resolution enlarger configured to acquire the set of decoded pictures from the first encoder to implement thereon a process for a second super-resolution enlargement to create a set of super-resolution enlarged decoded pictures with a resolution higher than the standard resolution; and
[3.4]	a third encoder configured to have the set of super-resolution enlarged pictures from the first super-resolution enlarger as a set of encoding target pictures, employing the set of super-resolution enlarged decoded pictures from the second super-resolution enlarger as a set of reference pictures, to implement thereon a third combination of processes for a prediction and an encoding to create a third sequence of encoded bits,
[3.5]	wherein a spatial resolution of the set of super-resolution enlarged pictures, and that of the set of super-resolution enlarged decoded pictures are made equal; and
[3.6]	wherein the third encoder controls a selection of a set of reference pictures and creates a set of data on the selection of the set of reference pictures to identify a selected set of reference pictures during the process for prediction of the third combination.

C. Examination History

35. The '448 Patent issued on May 26, 2015 from U.S. Patent Application No. 12/995,039 (“the '039 application”), which was filed on November 29, 2010 with originally 26 claims. *See* APPLE-1002, 15-25 (NOA), 271-288 (original claims).

36. The Examiner mailed only a single office action during prosecution. In the non-final action of May 15, 2014, the Examiner rejected the pending claims as obvious over Wan (APPLE-1075) in view of Phek (APPLE-1005) and Holcomb (APPLE-1024). *See* APPLE-1002, 90-107 (Non-final rejection), 197-203 (OA Election/restriction). The Examiner asserted that Wan’s scalable video encoding system, when modified by Phek’s super-resolution processing and Holcomb’s multi-resolution techniques, would render application claims 7–9 (corresponding to issued claims 1-3) obvious. In response, the applicant amended the claims by adding further detail to the claim preambles and adding the limitations recited in elements [1.6]-[1.7] of the issued claims. On January 22, 2015, following the applicant’s response, the Examiner issued a notice of allowance. *See* APPLE-1002, 56-75 (amended claims in applicant response), 76-82 (applicant argument to the OA), 15-25 (NOA). Based on my review, the Examiner’s reasons for allowance reflect an erroneous belief that the prior art did not disclose or render obvious the predictable collection of conventional features recited by each of claims 1-3. *Id.*

VI. Person of Ordinary Skill in the Art

37. It is my understanding that the patentability of the claims of the '448 Patent must be assessed from the perspective of a person of ordinary skill in the art at the time of the alleged invention ("POSITA"). For purposes of my analysis in this declaration, I have taken the earliest claimed priority date of the '448 Patent (May 30, 2008) as the date of the alleged invention ("Critical Date"). I understand that the factors considered in determining the ordinary level of skill in a field of art include the level of education and experience of persons working in the field; the types of problems encountered in the field; the teachings of the prior art, and the sophistication of the technology at the time of the alleged invention. I understand that a POSITA is not a specific real individual, but rather is a hypothetical individual having the qualities reflected by the factors above. I understand that a POSITA would also have knowledge from the teachings of the prior art, including the art cited below.

38. Taking these factors into consideration, it is my opinion that one of ordinary skill in the art in the field of digital video coding as of the Critical Date, would have had a bachelor's degree in computer science, electrical engineering, computer engineering, or a related field, with 2-3 years of experience in digital video processing, or a related field. Additional graduate education could substitute

for professional experience, or additional professional experience could substitute for formal education.

39. I have possessed the qualifications of a POSITA since the Critical Date of the '448 Patent, and long before.

VII. Claim Construction

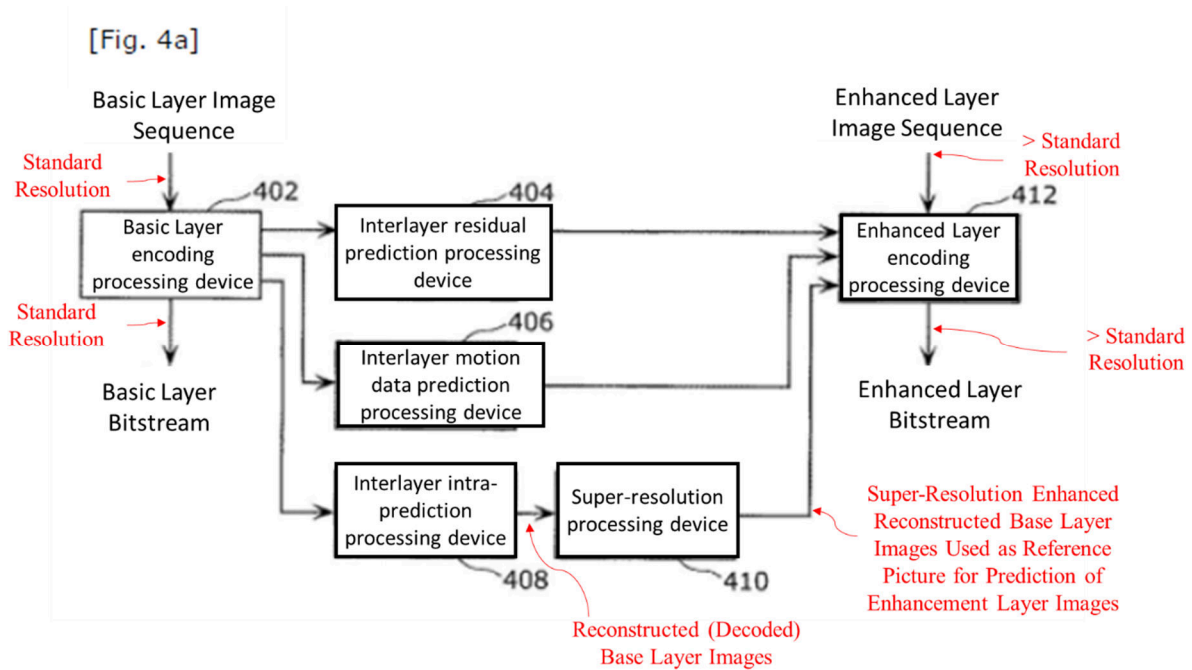
40. I have not been asked to opine on the special meanings of claim terms within the '448 patent. I have been informed that the claim terms should be afforded their ordinary meaning in view of the specification and file history. By addressing the relevance of the prior art to the various terms and limitations in claims 1, 2, and 3, I have not intended to formally construe any claim terms and I have not formed an opinion as to whether these terms are definite or supported by the specification of the '448 Patent.

VIII. Ground 1A – Obviousness based on Phek-Segall-He

A. Overview of Phek

41. Phek discloses a video coding system that uses “[i]nterlayer prediction ... for hierarchical encoding in order to improve encoding efficiency.” APPLE-1005, [0014]. “One example of hierarchical encoding that uses interlayer prediction is ... scalable video encoding.” *Id.* Phek’s interlayer coding system includes a basic layer and an enhanced layer, where “an intra image of the basic layer or a reconstructed image of the basic layer” is used “as an additional reference

image for encoding the image of the enhanced layer.” *Id.* Moreover, “super-resolution processing ... is used to improve these additional reference images” from the basic layer. *Id.*; *see also id.*, [0011]-[0020], FIGS. 1a-1b, 3a-3b, 4a-4b, 5.

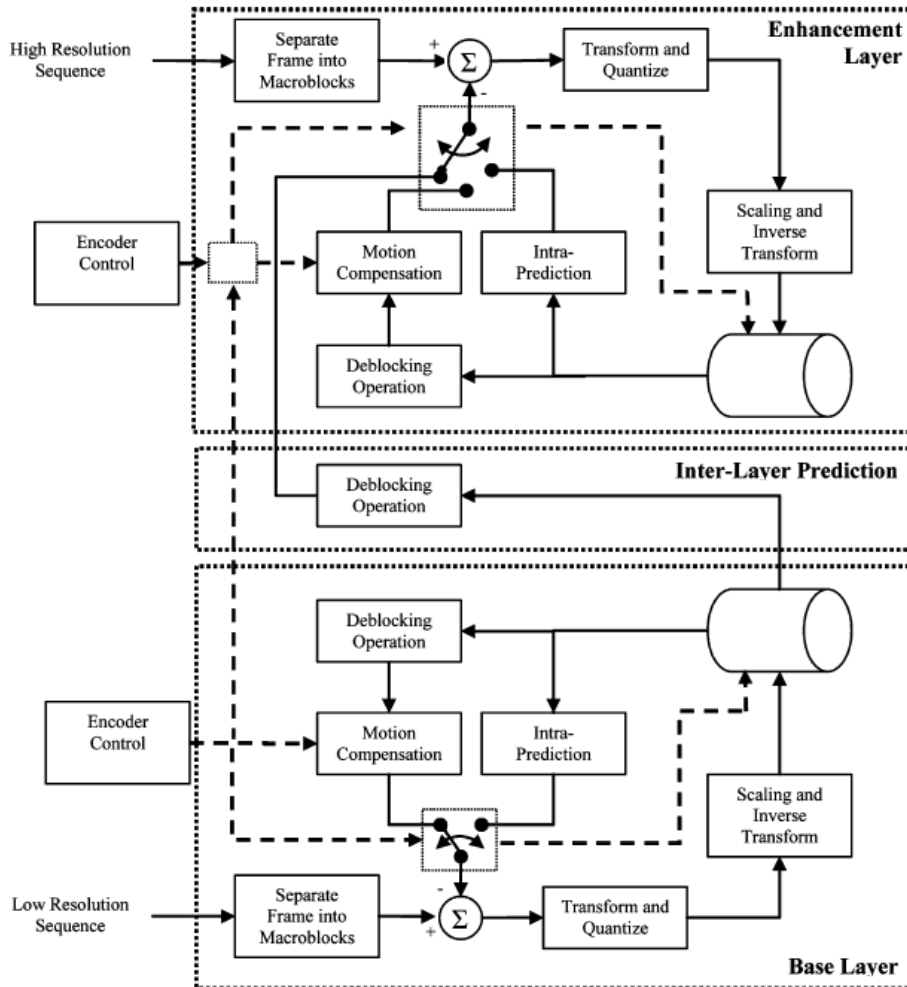


APPLE-1005, FIG. 4a (annotated).

B. Overview of Segall

42. Segall is an IEEE paper titled “Spatial Scalability Within the H.264/AVC Scalable Video Coding Extension.” APPLE-1006, §I. Segall surveys aspects of the scalable video coding (SVC) extension that “provide[] support for multiple display resolutions within a single compressed bit stream (or in hierarchically related bit streams), which is referred to [] as *spatial scalability*.” *Id.* (emphasis in original). Segall describes spatial scalability with reference to a

layered coding system that, like Phek’s system, employs inter-layer prediction as illustrated in FIG. 1:



APPLE-1006, FIG. 1

43. According to Segall, “[t]he ‘base layer’ encoder takes a lower resolution video sequence as input and encodes it with the H.264/AVC video coding standard while conforming to a legacy profile.” APPLE-1006, §II. “The enhancement layer encoder takes a higher resolution sequence as input” and encodes it “with ordinary H.264/AVC technologies.” *Id.* “Moreover, inter-layer

prediction can be used to provide additional coding choices” and “reconstructed intensities provide a prediction for the enhancement layer.” *Id.* Segall’s system “up-samples the decoded samples of the lower resolution layer to form a prediction” and “[t]hen, when indicated by the encoder, it receives residual difference information in the enhancement bit stream and adds this residual difference data to the prediction.” *Id.*, §III.C; *see also id.*, (“up-sampled to the higher resolution grid”), §III.A (“Calculation of Corresponding Spatial Positions” using “up-sampled lower resolution picture array”).

C. Overview of He

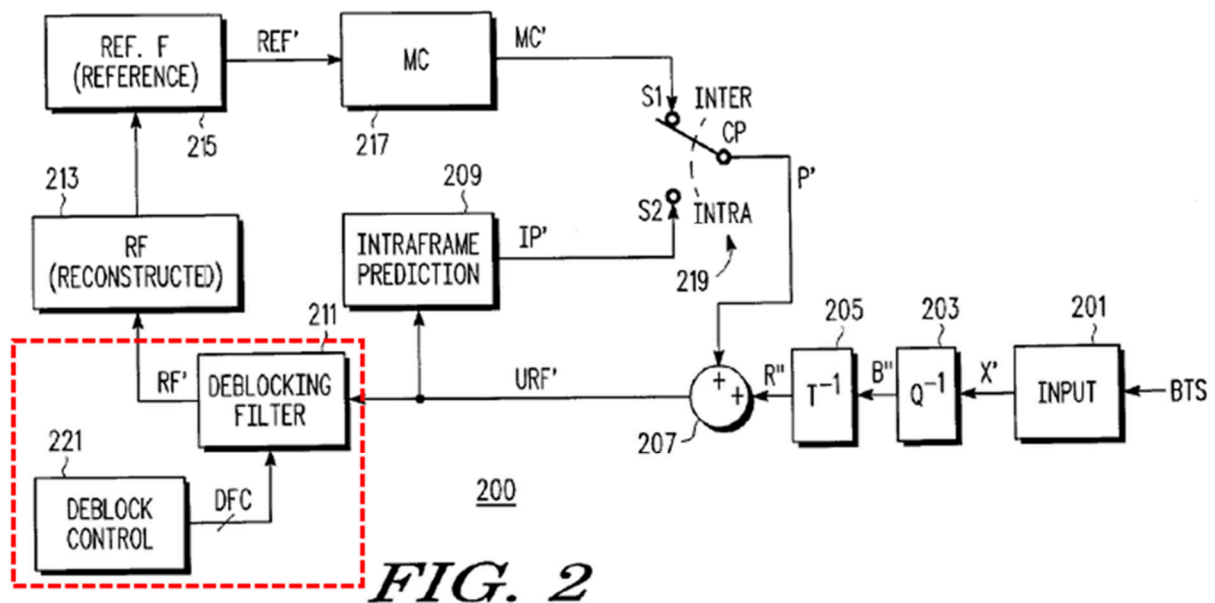
44. He discloses techniques for selective in-loop filtering in a scalable video coding system. He specifically focuses on selectively enhancing reference pictures via in-loop deblock filtering to control deblock filtering parameters at each layer of a scalable coding hierarchy. APPLE-1008, [0002]-[0006], [0022], [0028], [0032]-[0037], FIGS. 1-4.

45. According to He, “[t]he deblocking filter enhances the decoded picture quality and increases the encoding efficiency by removing the block effects in the boundary of each 4x4, 8x8, and/or 16/16 block,” although “[t]he deblocking filter[] ... also consumes a significant amount of power and processing cycles.” APPLE-1008, [0006]. “Disabling the entire deblocking filter [] provides a significant reduction of computational complexity and power consumption, especially in the

decoder of a video processing system.” *Id.*, [0028]. He thus proposes techniques for examining “the content of the video information ... to determine whether to disable the deblock filtering,” e.g., based on “a characteristic indicative of a relative amount of content complexity and/or a relative amount of motion of the video information” and “also based on power savings considerations.” *Id.*, [0028], [0037].

46. FIG. 2 (reproduced below) depicts a video decoder 200 configured to implement selective deblock filtering. APPLE-1008, [0032], FIG. 2. The decoder 200 receives a coded bitstream (BTS) and performs prediction and reconstruction operations to decode at least a portion of a picture, thereby generating “unfiltered reconstructed frame information URF’.” *Id.*, [0032]. URF’ is provided to a deblocking filter 211, controlled by a deblock control circuit 221. *Id.*, [0033]-[0034]. Deblock control circuit 221 issues a “decoder filter control DFC signal” that selectively enables or disables the deblocking filter 211. *Id.*, [0034]. When filter 211 is disabled, deblock filtering operations are bypassed and “URF’ is passed as the ‘filtered’ reconstructed information RF’ to a reference frame buffer 213 for use as a reference picture for motion-compensated prediction processes. *Id.* When filter 211 is enabled, URF’ is filtered to generate RF’ for use as a reference picture in the motion compensated prediction processes. *Id.*

47. He further explains that “the video encoder 100 provides control information within the bitstream BTS to cause the deblock control circuit 221 of the video decoder 200 to provide the DFC signal to adaptively disable deblock filtering for a corresponding slice or frame of URF’ information being processed in the video decoder 200.” APPLE-1008, [0034].



In-Loop Deblocking Filter 211 and
Control Circuit 221

APPLE-1008, FIG. 2 (annotated); APPLE-1046 ([0131], [0253], FIGs. 6, 12, 15).

D. Combination of Phek, Segall, and He

48. Like the '448 Patent, Phek discloses a layered video coding system that processes decoded base layer pictures to create reference pictures for the prediction of pictures in an enhancement layer. *Supra*, §IV.A-B. While Phek's disclosure focuses on details of a super-resolution algorithm used to enhance decoded base

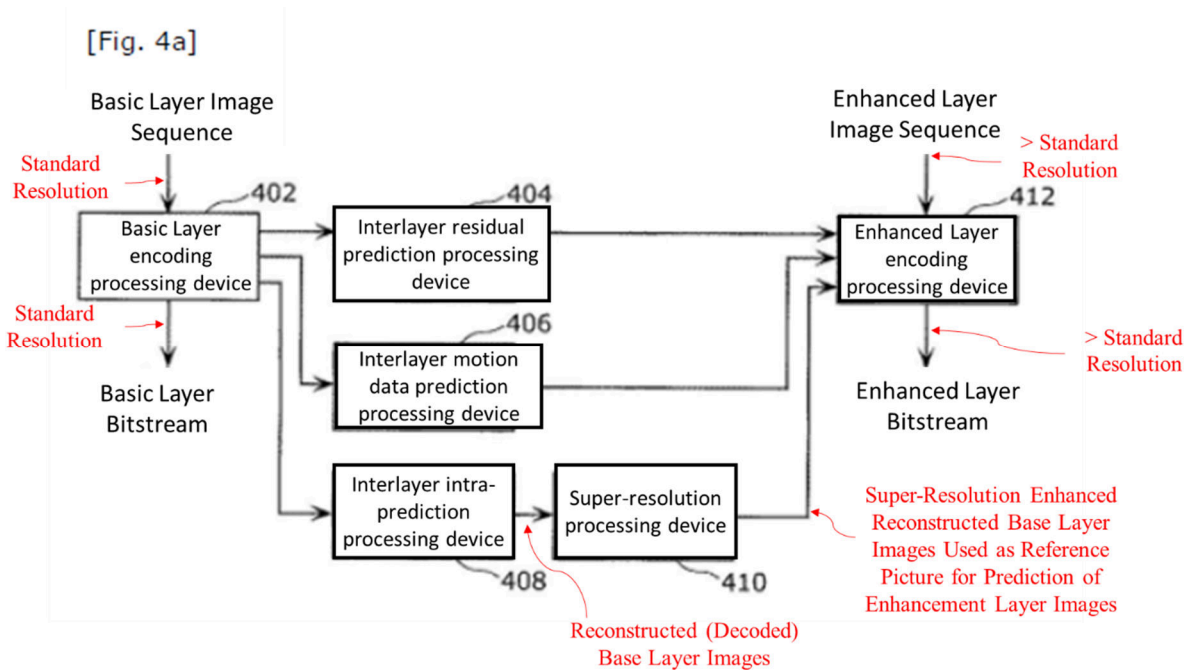
layer pictures, Phek's description of the layered coding system itself (which uses the proposed super-resolution algorithm) is less detailed. Indeed, Phek acknowledges that its encoder/decoder descriptions are "simplified" and "do not have to be performed as shown." APPLE-1005, [0013]. Phek's system is ripe for improvement.

49. As described below, a POSITA reviewing Segall and He would have found it obvious to modify Phek's layered coding system in at least the following ways.

(a) **Obvious based on Phek to form an enhancement layer video input by super-resolution processing a base layer video input**

50. Phek teaches that "Fig. 4a and Fig. 4b are two block diagrams showing use of a super-resolution processing device for intra-layer prediction in, respectively, an encoding device (encoder) and decoding device (decoder)." APPLE-1005, [0014]. According to Phek, "[i]nterlayer prediction is used for hierarchical encoding in order to improve encoding efficiency" and "[o]ne example of hierarchical encoding that uses interlayer prediction is ... known as scalable video encoding." *Id.* As shown in FIG. 4A, "[a] basic layer image sequence is encoded using a basic layer encoding processing device 402" and "[a]n enhanced layer image sequence is encoded using an enhanced layer encoding processing device 412," where "[t]he enhanced layer encoding processing device 412 uses

interlayer prediction to reduce redundancy between the enhanced layer and the basic layer, thereby improving encoding efficiency compared to encoding performed using only an enhanced layer.” *Id.*



APPLE-1005, FIG. 4A.

51. To the extent Phek does not expressly describe how the enhanced layer image sequence encoded by enhanced layer encoding processing device 412 is formed, it would have been obvious for the enhanced layer image sequence to be formed by applying Phek’s super-resolution processing to the base layer image sequence. Multiple reasons would have prompted a POSITA to apply Phek’s super-resolution processing to the base layer image sequence to generate the enhanced layer image sequence.

52. First, a POSITA would have recognized Phek's super-resolution processing technique as a known and beneficial option for *enhancing* a video stream. It therefore would have been obvious and beneficial to generate an enhanced layer image sequence to achieve Phek's express goal of obtaining such an *enhanced* layer image sequence for encoding. Indeed, Phek specifically teaches that its "super-resolution processing method ... improves the resolution and quality of image sequences" while "reduc[ing] grid artifact[s]" in the enhanced images. APPLE-1005, (57); *see also id.*, [0002] ("Super-resolution processing is a technique for generating high-resolution images from a plurality of low-resolution images. This technique can be used ... to improve the resolution and quality of the imputed image sequences to be displayed."), [0003] ("improved by repeatedly subjecting [an estimated frame] to blurring, frame difference, point spreading inverse function, regularization, and refinement processing"), [0011] ("present invention uses a super-resolution processing device 320 to improve the quality and resolution of reference frames"), [0013] ("super-resolution processing can be used in encoders and decoders to improve encoding efficiency or picture quality"). Considering the quality- and resolution-based enhancements offered by super-resolution processing—which are expressly touted in Phek—super-resolution processing would have been obvious to use in forming an enhanced layer image

sequence that could be encoded by the enhanced layer encoding processing device 412.

53. Second, a POSITA would have recognized that applying super-resolution processing to the base layer image sequence to produce an enhanced layer image sequence for encoding is consistent with Phek's multiple teachings for applying super-resolution processing before encoding/compression. To this point, Phek explains that "[w]hen super-resolution processing is used in recording devices ..., *the resolution and quality of images subject to transcoding and storage can be improved.*" APPLE-1005, [0002] (emphasis added). Phek also discloses with respect to FIG. 2 that super-resolution processing can be used in a "pre-processing device" that obtains an uncompressed image sequence D254 and that thereafter applies super-resolution processing to produce a super-resolution image sequence D266 that can be displayed, stored, or *compressed* (which a POSITA would have understood to include encoding). APPLE-1005, [0010] ("[c]ompression may also be used"), FIG. 2. Thus, even if Phek does not specifically discuss details of the enhanced layer image sequence encoded by the system shown in FIG. 4A, Phek does expressly disclose how a source image sequence D254 akin to the base layer image sequence of FIG. 4A can be enhanced by super-resolution processing and subsequently encoded. *Id.* In this context, a POSITA would have understood and found it obvious to apply Phek's own

enhancement technique (i.e., super-resolution processing) to obtain an enhanced layer image for encoding by the layered encoding system of FIG. 4A.

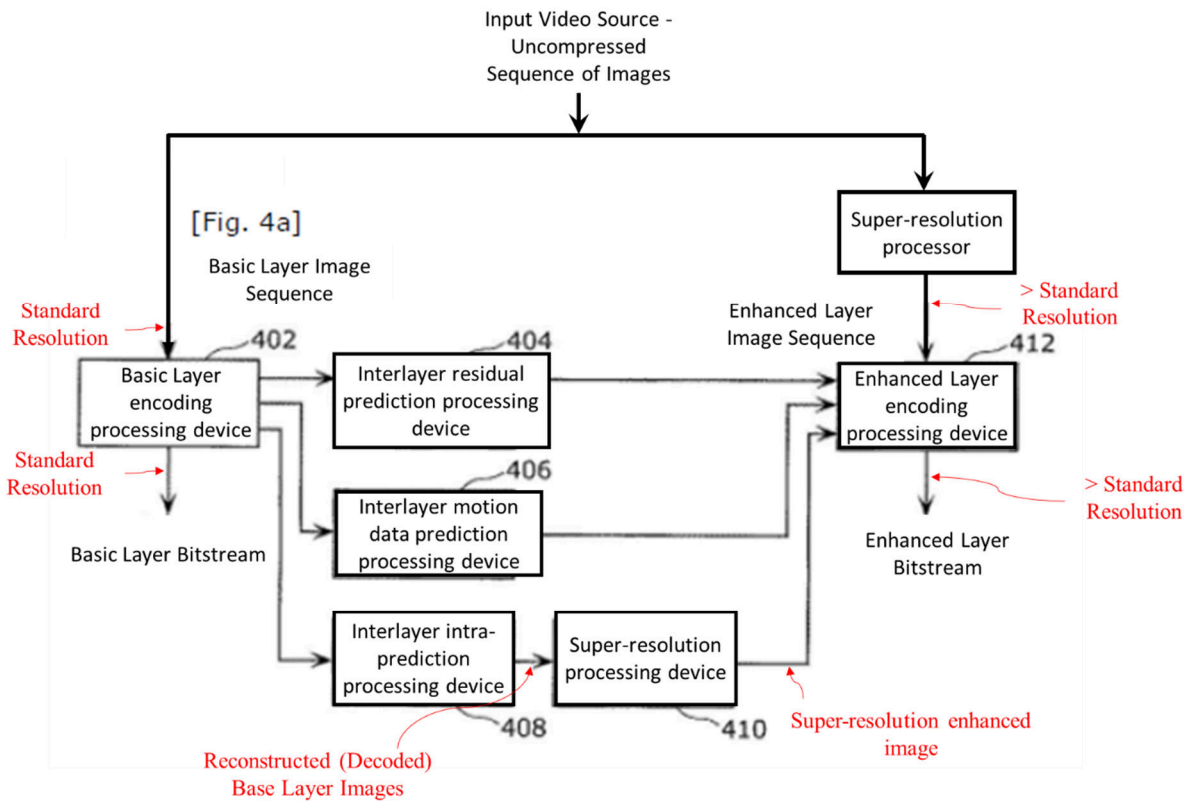
54. Third, a POSITA would have sought to form the enhanced layer image sequence by applying super-resolution processing to the base layer image sequence to produce an enhanced layer image sequence that is related to the base layer image sequence. The relationship between the two image sequences would have improved coding efficiency because the layered coding system removes significant redundancies between the base layer image sequence and the enhanced layer image sequence during coding. *Id.*; APPLE-1005 , [0014] (“Interlayer prediction is used for hierarchical encoding in order to improve encoding efficiency. ... The enhanced layer encoding processing device 412 uses interlayer prediction to reduce redundancy between the enhanced layer and the basic layer, thereby improving encoding efficiency compared to encoding performed using only an enhanced layer.”). Super-resolution processing also has the effect of both increasing the quality (e.g., information content, signal-to-noise ratio (SNR)) and size/spatial resolution of an input image sequence, which are two characteristics of base and enhancement layer image sequences that are commonly differentiated between layers of a scalable video coding system like that disclosed in Phek. APPLE-1005, (57), [0002]-[0004], [0011], [0013]; APPLE-1010, 1104 (“The usual modes of scalability are temporal, spatial, and quality scalability. Spatial scalability and

temporal scalability describe cases in which subsets of the bit stream represent the source content with a reduced picture size (spatial resolution or frame rate (temporal resolution), respectively. With quality scalability, the substream provides the same spatial-temporal resolution as the complete bit stream, but with a lower fidelity—where fidelity is often referred to as signal-to-noise ratio (SNR). ... The different types of scalability can also be combined, so that a multitude of representations with different spatial-temporal resolutions and bit rates can be supported within a single scalable bit stream.”), 1103. A POSITA thus would have recognized super-resolution processing as a beneficial technique for generating an enhanced layer image sequence that could be suitably encoded by a layered/scalable coding system as taught in Phek.

55. Fourth, a POSITA would have sought to form the enhanced layer image sequence through super-resolution processing to overcome limitations that may have suppressed the quality and size of the original input video (base layer image sequence). For example, the original input video may have been captured using a camera that was only capable of recording video at standard definition (e.g., 480i or 480p), but a user may have a need or desire to code and transmit the video for viewing in high definition (e.g., 1080i or 1080p) to increase viewer satisfaction, and to better utilize the higher-resolution display capabilities of the receiver. In this case, super-resolution processing would have been obvious and beneficial to

enhance the quality and resolution of the original standard definition video, so that the video could be later coded, decoded, and viewed at a higher definition. *Id.* Moreover, by performing super-resolution at the encoding system before compression and storage or transmission of the video, the viewer's device would beneficially be able to view the video at a higher quality and resolution simply by decoding the enhancement layer stream, without need to further apply super-resolution post-processing to a decoded version of the base layer image sequence at the receiver/viewing device. *Id.*; *see also* APPLE-1007, 804-805 (describing super-resolution post-processing performed at the receiver/viewing device).

56. Fifth, a POSITA would have found it obvious to generate Phek's enhanced layer image sequence by applying super-resolution processing to the base layer image sequence because doing so merely entails the predictable application of known technique (e.g., super-resolution processing) to a known system (e.g., Phek's layered coding system) to achieve predictable results. Here, Phek expressly describes how to perform super-resolution processing and the implementation of such techniques was well within the capability of a POSITA. A POSITA would have reasonably expected success using super-resolution to form the enhanced layer image sequence in Phek's system, especially since such super-resolution techniques were well known and expressly taught by Phek before the Critical Date.



First Intermediate Illustration of Proposed Combination (Phek)

- (b) **Obvious based on Segall to form enhancement layer reference pictures by applying conventional resolution conversion to upscale decoded base layer pictures**

57. Phek's interlayer predictive encoding device of FIG. 4A "use[s] ... a super-resolution processing device for intra-layer prediction." APPLE-1005, [0014], FIG. 4A. "The interlayer intra-prediction processing device 408 uses an intra image of the basic layer or a reconstructed image of the basic layer as an additional reference image for encoding the image of the enhanced layer," and "[a] super-resolution processing device 410 is used to improve these additional

reference images.” *Id.* As discussed, super-resolution processing has the effect of both increasing the spatial resolution of an image and improving quality of the image by adding detail based on information about a scene obtained from nearby frames in a video image sequence. *Id.*, [0002] (“improve the resolution and quality of the inputted image sequences to be displayed”), [0004], [0016]; APPLE-1012, 22 (“The basic premise for increasing the spatial resolution in SR [super-resolution] techniques is the availability of multiple LR [low-resolution] images captured from the same scene In SR, typically, the LR images represent different ‘looks’ at the same scene. That is, LR images are subsamples (aliased) as well as shifted with subpixel precision. ... In this case, the new information contained in each LR image can be exploited to obtain an HR [high-resolution] image.”). By applying super-resolution processing to intra- or reconstructed images of the base layer, Phek’s encoding device increases the spatial resolution of decoded base layer images so that they can be used as a reference for prediction of higher-resolution enhancement layer images. *See also*, APPLE-1024, 6:8-43, 6:64-7:21, FIG. 2 (referring to resolution converters 210 and 230); APPLE-1026, 25:27-37, FIG. 1 (referring to resolution converter 205); APPLE-1050, [0053]-[0058], [0098], FIGs. 3, 14 (illustrating upsampling process); APPLE-1051, FIGs. 1, 21, [0164]; APPLE-1052, [0110], [0060]-[0079], FIGs. 3-5, 9; APPLE-1053, [0034], [0123]-[0140], [0152]-[0162], FIGs. 2d, 6b, 5a-d; APPLE-1076, 5:63-

6:56, 8:14-57, FIGs. 3A-B. Coding higher-resolution images at an enhancement layer was commonly performed in systems like Phek's, particularly in the context of spatial scalability. *See also* APPLE-1006, 1 ("The SVC [scalable video coding] extension ... provides a mechanism for reusing an encoded lower resolution version of an image sequence for the coding of a corresponding higher resolution sequence.")

58. Although Phek discloses the option of super-resolution processing as a means of increasing the spatial resolution of base layer images used for interlayer prediction, a POSITA would have understood that other techniques could also be used to increase the spatial resolution of an image—including in the context of forming higher-resolution reference pictures for interlayer prediction. APPLE-1073, [0052] ("The super-resolution processor 120 uses multiple frames of the input image to generate a high-resolution image. ... [T]he processing content of the super-resolution processing unit does not necessarily have to be super-resolution processing as described in the prior art section, and the processing content is not particularly limited as long as it is processing that improves the resolution of the input image."). In general, reference pictures for image prediction can be prepared using any suitable technique so long as the reference picture sufficiently approximates the target image that is to be predicted/decoded. *See also*, APPLE-1017, 6:6-23, 7:39-44; APPLE-1050, [0079]; APPLE-1015, [0010],

[0014], [0018]-[0019], FIG. 1 (referring to reference picture buffer 180); APPLE-1062, FIG 1; APPLE-1005, [0014]. Better compression can typically be achieved when the reference picture more closely approximates the target image. However, the desire for high-quality reference pictures would have been balanced by a POSITA against the increased computational expense needed to generate such pictures—i.e., computational expense that can increase coding time, increase power consumption, and increase the cost of hardware needed to support the additional processing complexity attendant to the use of higher-quality reference pictures. APPLE-1008, [0005]-[0006], [0009], [0028]-[0029], [0037], [0049].

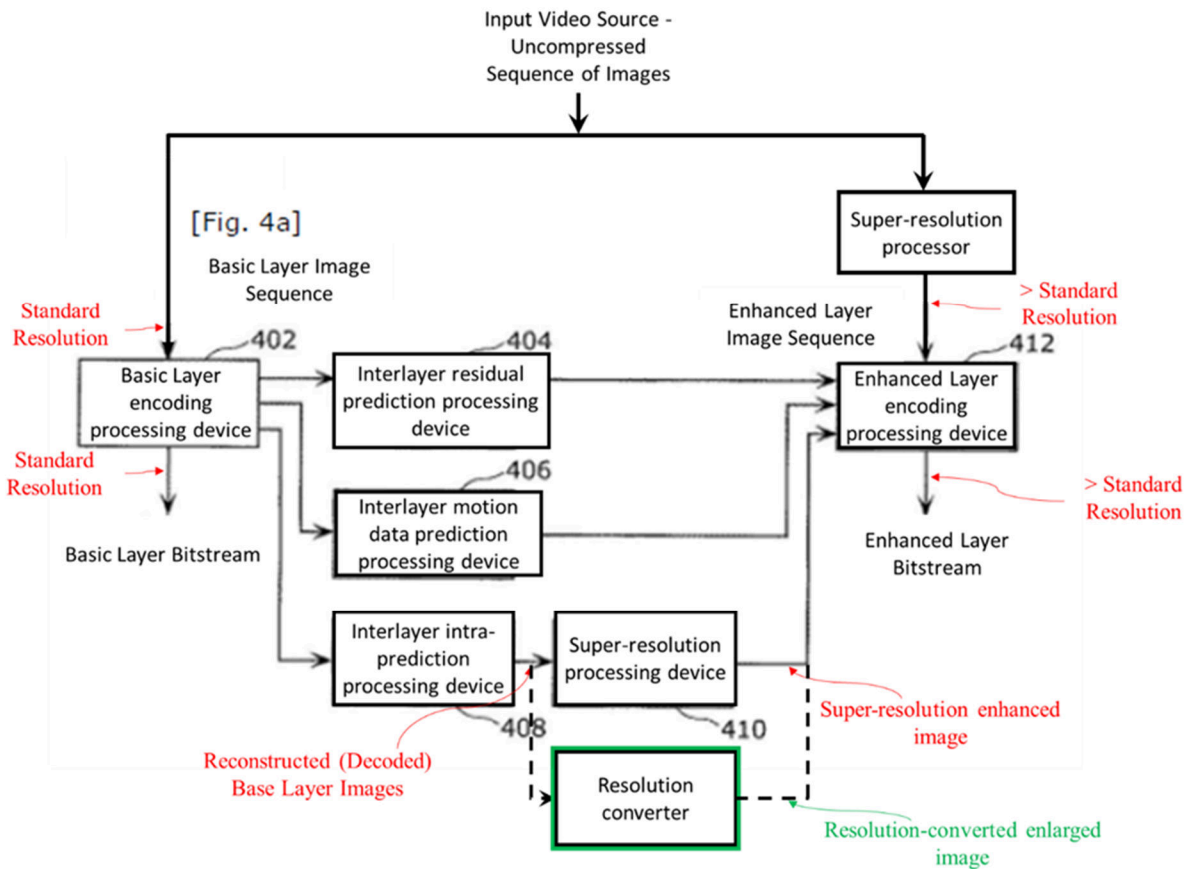
59. With these considerations in mind, and recognizing that super-resolution processing is a computationally expensive technique for increasing the spatial resolution of an image, a POSITA would have looked for additional or alternative methods beyond Phek's super-resolution processing that could achieve the same result of increasing the spatial resolution of decoded base layer images used as reference pictures for interlayer prediction (even if the quality/detail of the base layer images is not improved). *See also* APPLE-1055, [0014] (explaining with respect to super-resolution processing that “the runtime of image reconstruction by the iterative method ... depends on the performance of computer system”); APPLE-1074, 4:60-67 (“Inter-frame methods such as super-resolution attempt to fuse sub-pixel (or “sub-sample”) detail that has been scattered over

several pictures by aliasing and other diffusion methods, and can in fact restore definition above the Nyquist limit implied by the standard definition sampling lattice. However such schemes are computationally expensive, non-linear, and do not always yield consistent quality gains frame-to-frame.”).

60. Segall discloses one such conventional resizing technique for upscaling/resolution conversion applied to increase the spatial resolution of a base layer image used as a reference picture in a scalable coding system, although without the high computational demands of super-resolution processing. For example, Segall discloses “up-sampl[ing] the decoded samples of the lower resolution layer to form a prediction.” APPLE-1006, 6. “The up-sampling operation for the luma component consists of applying a separable four-tap poly-phase interpolation filter” while “[t]he chroma component of the signal is also up-sampled but with a different (simpler) interpolating kernel.” *Id.*; *generally id.*, §§III.A (describing detailed techniques for up-sampling and calculation of corresponding spatial positions between base and enhancement layer images), III.C (describing details of up-sampling decoded samples of the lower layer), FIG. 1. Segall’s teachings are illustrative of a class of well-known resolution conversion techniques that serve to increase image resolution by interpolating additional pixels in an image from other pixels within the same image, but without the need for a series of images as required by super-resolution processing. *See, e.g.*, APPLE-

1012, 22-23 (“[I]mage interpolation ... has been used to increase the size of a single image. ... [S]ingle image interpolation cannot recover the high-frequency components lost or degraded during the LR [low-resolution] sampling process. For this reason, image interpolation methods are not considered as SR [super-resolution] techniques.”); APPLE-1074, 4:53-60 (“Prior art interpolation methods can interpolate a standard definition video signal to, for example, a high definition display, but do not add or restore content beyond the limitations of the standard-definition sampling lattice. Prior art methods include, from simplest to most complex: sample replication (“zero order hold”), bi-linear interpolation, poly-phase filters, spline fitting, POCS (Projection on Convex Sets), and Bayesian estimation.”). Indeed, resolution conversion based on conventional interpolation techniques like those disclosed in Segall were commonly used by the Critical Date of the ’448 patent to adjust the size of reference pictures in scalable coding systems. *See, e.g.*, APPLE-1024, 6:8-43 (disclosing resolution converters (210 and 230) as standard components in multi-resolution encoding systems that receive input frames and output converted frames with parameters for use by other encoder modules), FIG. 2; APPLE-1026, 25:27-37 (“converts the resolution of the base layer image signal to the resolution corresponding to the enhancement image signal by means of filtering operation.”), FIG. 1 (depicting resolution converter 205).

61. A POSITA would have been motivated based on Segall to implement a conventional interpolation-based resolution converter in Phek's system as an alternative to super-resolution processing for increasing the resolution of decoded base layer pictures used as reference pictures in the enhancement layer. The use of a conventional interpolation-based resolution converter in Phek's system would have been obvious and beneficial to increase the size of the decoded base layer pictures as needed for prediction in the enhancement layer, and to do so in a less computationally demanding manner than would be required by super-resolution processing. *Id.* Conventional interpolation-based resolution conversion would balance processing complexity against image quality, and would predictably require less time/processing cycles, less power consumption, and less costly hardware (e.g., less memory and processing capability) than super-resolution processing.



Second Intermediate Illustration of Proposed Combination (Phek-Segall)

62. A POSITA would have recognized that the addition of a conventional resolution converter represents a straightforward implementation of Segall's spatial scalability architecture within Phek's hierarchical encoding framework. APPLE-1005, [0014]; APPLE-1006, §II. Segall explicitly teaches the "calculation of corresponding positions in different resolution layers" and "methods for inter-layer prediction of various data," providing the technical foundation for implementing conventional resolution conversion alongside super-resolution processing. APPLE-1006, §II. The resulting combination maintains the system's ability to "enhance the quality of interlayer prediction" while introducing a

resolution conversion pathway that offers reduced computational complexity for appropriate images. APPLE-1005, [0014].

63. The use of a conventional resolution converter also addresses practical implementation considerations for system designers. APPLE-1005, [0014]. Segall recognizes that “one potential approach” to scalable encoding “would be to perform multiloop decoding,” but notes that a “lower complexity approach is adopted” in scalable coding designs. APPLE-1006, §II. The conventional resolution converter implements a lower-complexity approach, providing a computationally efficient pathway that complements the more sophisticated super-resolution processing. APPLE-1055, [0030]. This configuration enables system designers to make targeted trade-offs between processing complexity and image quality, enhancing the system’s adaptability to diverse application requirements. APPLE-1005, [0014]; APPLE-1006, §II.

64. Finally, a POSITA would have found it obvious to apply Segall’s suggestion for interpolation-based resolution conversion to Phek’s system as the combination entails nothing more than the use of a known technique as taught by Segall to a known system as taught by Phek to achieve merely predictable results. Here, Segall expressly teaches how to use conventional interpolation-based resolution conversion techniques in a scalable coding system like Phek’s and the implementation of such techniques was well within the capability of a POSITA. A

POSITA would have reasonably expected success applying these techniques to Phek's system, especially since such techniques were well known and commonly implemented before the Critical Date. *Id.*

(c) Obvious based on He to implement reference picture selection functionality

65. As I addressed above, it would have been obvious based on Segall to increase the spatial resolution of decoded base layer pictures in Phek's system using conventional interpolation-based techniques as an alternative to super-resolution processing. *Supra*, §VIII.D.(b). The choice of whether to apply interpolation-based resolution conversion or super-resolution would be informed by known and predictable factors such as the compression efficiency achieved by each technique and the relative computational demands of the different techniques. For example, super-resolution processing typically yields a higher-quality reference picture that more closely predicts the decoding target in the enhancement layer (especially since the enhancement layer input stream is also super-resolution enlarged in the Phek-Segall-He combination (*see supra*, §VIII.D.(a))), and super-resolution processing can therefore increase compression efficiency for many images. However, despite potential gains in compression efficiency, super-resolution processing can also require more processing power, memory, and processing times than less complex interpolation-based upscaling methods like

those represented by Segall, which do not require processing a series of images to resolve a higher resolution image. *See also* APPLE-1012, 22-23; APPLE-1074, 4:53-67; APPLE-1024, 6:8-43, FIG. 2; APPLE-1026, 25:27-37, FIG. 1; APPLE-1006, 1-6. A POSITA would have recognized that, in some cases, the improvements in compression efficiency and/or image quality achieved by enlarging reference pictures using super-resolution processing rather than conventional single-image interpolation methods do not justify the increased processing demands associated with super-resolution enlargement. In other cases, the benefits attendant to enlarging reference pictures by super-resolution would be insignificant and would not justify the requisite increase in processing demands since conventional single-image interpolation methods would yield comparable compression efficiency and image quality. *Id.*; *see also* APPLE-1073, [0052]. Accordingly, a POSITA would have looked for options to realize the benefits of both approaches (i.e., super-resolution enlargement and single-image interpolation-based resolution conversion) and thereby optimize compression efficiency, image quality, and memory/processor utilization during the coding process.

66. He teaches one such option that would have been obvious to apply in combination with Phek and Segall to optimize the selection of reference pictures in Phek's enhancement layer coding process. As discussed, He discloses

techniques for selectively enhancing reference pictures via in-loop filtering in a scalable video coding system. *Supra*, §IX.C. For example, He describes selective in-loop deblock filtering to control deblock filtering parameters at each layer of a scalable coding hierarchy. APPLE-1008, [0002]-[0006], [0022], [0028], [0032]-[0037], FIGS. 1-4. According to He, “[t]he deblocking filter enhances the decoded picture quality and increases the encoding efficiency by removing the block effects in the boundary of each 4x4, 8x8, and/or 16/16 block,” although “[t]he deblocking filter[] ... also consumes a significant amount of power and processing cycles.” APPLE-1008, [0006]. “Disabling the entire deblocking filter [] provides a significant reduction of computational complexity and power consumption, especially in the decoder of a video processing system.” *Id.*, [0028]. He proposes techniques for examining “the content of the video information ... to determine whether to disable the deblock filtering,” e.g., based on “a characteristic indicative of a relative amount of content complexity and/or a relative amount of motion of the video information” and “also based on power savings considerations.” *Id.*, [0028], [0037]. Based on results of this examination, He uses a switching signal to selectively enable or disable the reference picture enhancement deblocking filter. APPLE-1008, [0034], FIG. 2.

67. He thus describes a switching capability that allows a video coder to selectively activate or de-activate a reference picture enhancement process. While

He addresses de-block filtering as an example reference picture enhancement process, in the context of the Phek-Segall combination, the implicated reference picture enhancement is super-resolution enlargement. *Supra*, §VIII.D.(b). That is, as compared to conventional resolution conversion techniques as taught by Segall, Phek's super-resolution enlargement further enhances reference pictures by adding detail to a depicted scene indicated by other images. *Supra*, §VIII.D.(b); APPLE-1005, [0002] (explaining that super-resolution processing "improve[s] the resolution *and quality* of the inputted image sequences"); APPLE-1012, 2-3 ("single image interpolation cannot recover the high-frequency components" and "[f]or this reason, image interpolation methods are not considered as SR [super-resolution] techniques"). A POSITA reviewing He thus would have found it obvious and straightforward to similarly implement in the Phek-Segall system a switching capability that would allow selective use of the enhancements offered by super-resolution processing when forming reference pictures for interlayer prediction. For example, based on He's teachings, when content characteristics of the video indicate that the balance between coding efficiency and processing demands (e.g., power savings considerations) would be optimized by enhancing a reference picture, the system would apply super-resolution processing to the decoded base layer image to form the reference picture. APPLE-1008, [0028], [0034], [0037]. But when content characteristics of the video indicate that the

balance between coding efficiency and processing demands (e.g., power savings considerations) would be optimized by not enhancing a reference picture, the system would apply conventional single-image interpolation-based upscaling as suggested in Segall to the decoded base layer image to form the reference picture.

Id.

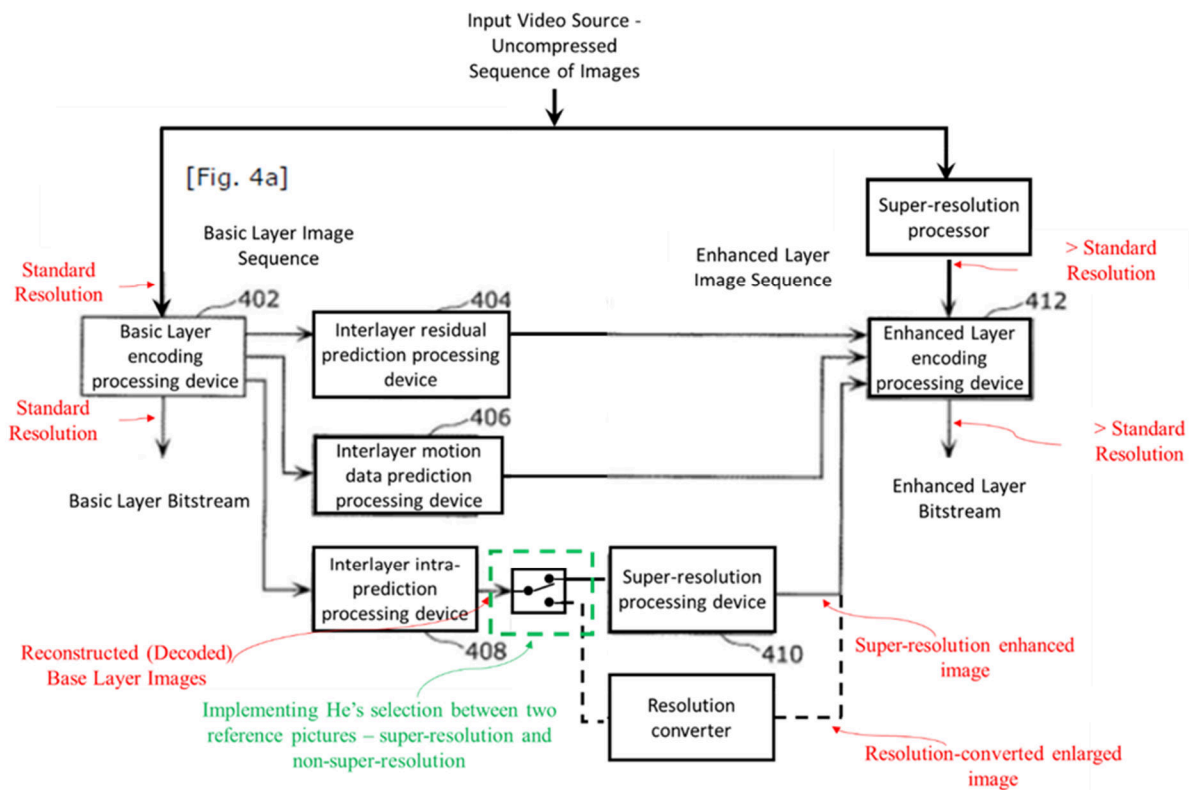


Illustration of Proposed Combination (Phek-Segall-He)

68. A POSITA would have been motivated to implement reference picture selection in the Phek-Segall-He combination to maintain the benefits of improved coding efficiency and picture quality offered by super-resolution processing while reducing the processing demands and power consumption of the system by using

conventional resolution conversion when super-resolution processing is less beneficial. A POSITA also would have sought to adopt such reference picture selection techniques because reference picture selection was a common and well-understood technique in the field before the Critical Date of the '448 Patent. *Id.* Even Phek and Segall acknowledge different forms of reference picture selection can be used to optimize the performance of a video coder. *See, e.g.*, APPLE-1005, [0014] (explaining that “an intra image of the basic layer or a reconstructed image of the basic layer [is used] as an **additional** reference image for encoding the image of the enhanced layer”); APPLE-1006, 3 (“Considerable flexibility is ... provided in regard to the selection of the reference layer”), 2 (“[I]nter-layer prediction can be used to provide **additional** coding choices.”); APPLE-1046, [0137]-[0140], [0176], [0251], FIG. 6 (describing reference picture selectors).

69. As depicted above, the system in the resulting combination would predictably allow the enhanced layer encoding processing device (412) to utilize reference pictures from either a super-resolution processing device like Phek’s or a resolution converter like Segall’s, optimizing the efficiency-quality tradeoff in hierarchical video coding systems. APPLE-1005, [0014]; APPLE-1006, §II. The implementation of He’s selection functionality directly addresses computational complexities that arise from Phek’s super-resolution processing. *See also* APPLE-1055, [0014]. The selective application of super-resolution processing only when

warranted by content characteristics provides a significant optimization of system resources. APPLE-1008, [0006]. He teaches that analogous enhancements like deblock filtering “consume a significant amount of power and processing cycles” and that selectively disabling such enhancements “provides a significant reduction of power and processing complexity, especially in the decoder.” APPLE-1008, [0006]. The selection functionality enables the system to route only appropriate content through the more intensive super-resolution path. APPLE-1008, [0069]. *See also* APPLE-1008, [0006]; APPLE-1015, [0068]; APPLE-1011, [0022]-[0023], FIGS. 2-5); *supra*, §II.A.

70. A POSITA further would have recognized that the significant computational burden of super-resolution processing makes selective application highly beneficial for system efficiency. *See also* APPLE-1055, [0014]. Second, the varying effectiveness of super-resolution enhancement across different content types creates a clear need for content-adaptive processing. *See also* APPLE-1055, [0070]. Third, the need to maintain high output quality while managing computational resources demands a flexible approach that can dynamically select the appropriate processing path. *See* APPLE-1008, [0069]. Implementation of this selection functionality follows established techniques in video coding. APPLE-1008, [0069]. He teaches that selective filtering allows systems to maintain a

“desired tradeoff between video quality and complexity reduction.” APPLE-1008, [0069].

71. A POSITA also would have found it obvious to apply He’s reference picture selection functionality to Phek’s system as the combination entails nothing more than the use of a known technique as taught by He to a predictable system as taught by Phek and Segall to achieve merely predictable results. Here, He expressly teaches how to use switching signals to selectively enable or disable reference picture enhancements in a scalable coding system like Phek’s and the implementation of such techniques was well within the capability of a POSITA. A POSITA would have reasonably expected success applying these techniques to Phek’s system, especially since such techniques were well known and commonly implemented before the Critical Date.

E. Analysis

72. As noted above, in preparing this declaration, I reviewed the IPR Petition that Apple is submitting to the PTAB to challenge claims 1-3 of the ’448 Patent. I collaborated with counsel in developing the grounds set forth in the Petition, and as such, the Petition itself reflects my analysis and opinions regarding the patentability of claims 1-3 of the ’448 Patent. Based on my review, the Petition correctly describes why the proposed prior art combinations would have been obvious to a POSITA and how the prior art combinations provide each element of

claims 1-3. Below, I highlight certain aspects of the Phek-Segall-He combination as described above and their relevance to various elements of claims 1-3 of the '448 Patent obvious . Additional explanation is provided in the Petition.

73. The first encoder element of claim 1, which operates on standard resolution moving pictures to create encoded bits and decoded pictures, finds correspondence in Phek's basic layer encoding processing device (402) as illustrated in the proposed combination. A POSITA would have understood that Phek's basic layer encoder implements conventional encoding and decoding processes operating on standard resolution video to produce both a compressed bitstream and decoded pictures that provide a foundation for subsequent enhancement layer processing. The basic layer encoding processing device performs encoding and decoding operations on standard resolution video, generating both the first sequence of encoded bits according to its compression algorithm and the set of decoded pictures through a reconstruction process at the standard resolution.

74. The first super-resolution enlarger element, which processes standard resolution moving pictures to create super-resolution enlarged pictures with higher resolution, corresponds to the super-resolution processor positioned in the enhanced layer processing path of the proposed combination. As illustrated in the combination diagram, this super-resolution processor receives the input video

source and implements Phek's super-resolution enlargement techniques to generate enhanced resolution pictures from the standard resolution input sequence. POSITA would have understood that this configuration represents a logical application of Phek's teachings, where super-resolution processing is applied to the original standard resolution video sequence to create higher resolution target pictures for enhanced layer encoding. The super-resolution processor operates on the input video stream to produce super-resolution enlarged pictures that serve as encoding targets for the enhanced layer.

75. The second super-resolution enlarger and third resolution converter elements acquire decoded pictures from the first encoder and apply different algorithms to create enlarged pictures with a resolution higher than the standard resolution. In the combination, Phek's super-resolution processing device (410) corresponds to a second super-resolution enlarger as claimed and the integration of Segall's teachings provides a third resolution converter as claimed. The super-resolution processing device (410) receives decoded pictures generated by the basic layer encoding processing device (402) and applies super-resolution enhancement techniques to generate super-resolution enlarged decoded pictures while the resolution converter implements conventional resolution conversion methods as taught in Segall to generate resolution-converted enlarged decoded pictures from the decoded base layer images. Both processing paths operate on the

same source material – the decoded images from the first encoder – but apply different enlargement algorithms to produce reference pictures with different characteristics for use in enhanced layer encoding. This dual-path approach provides the enhanced layer encoder with multiple reference picture options, each optimized for different prediction scenarios, thereby implementing the claimed functionality through well-established video processing techniques.

76. The third encoder element, which uses super-resolution enlarged pictures as encoding targets while selectively using either super-resolution enlarged decoded pictures or resolution converted decoded pictures as reference pictures for interlayer prediction, corresponds to the enhanced layer encoding processing device (412) in the combination. Further in the combination, the enhanced layer encoder (412) receives the super-resolution enlarged encoding target pictures from a first super-resolution processor. The enhanced layer encoder (412) is likewise configured to select between super-resolution enlarged decoded pictures from the super-resolution processing device (410) and resolution converted enlarged decoded pictures from the resolution converter as reference pictures for interlayer prediction. This configuration represents a natural extension of conventional multi-reference prediction techniques, where the availability of multiple reference picture types enhances coding efficiency through improved

motion compensation and residual prediction capabilities, for example as taught by He, and corroborated by Takahashi.

77. The following figure illustrates an example implementation of the proposed Phek-Segall-He combination in which the selection switch is configured to select a set of reference pictures that have undergone super-resolution processing:

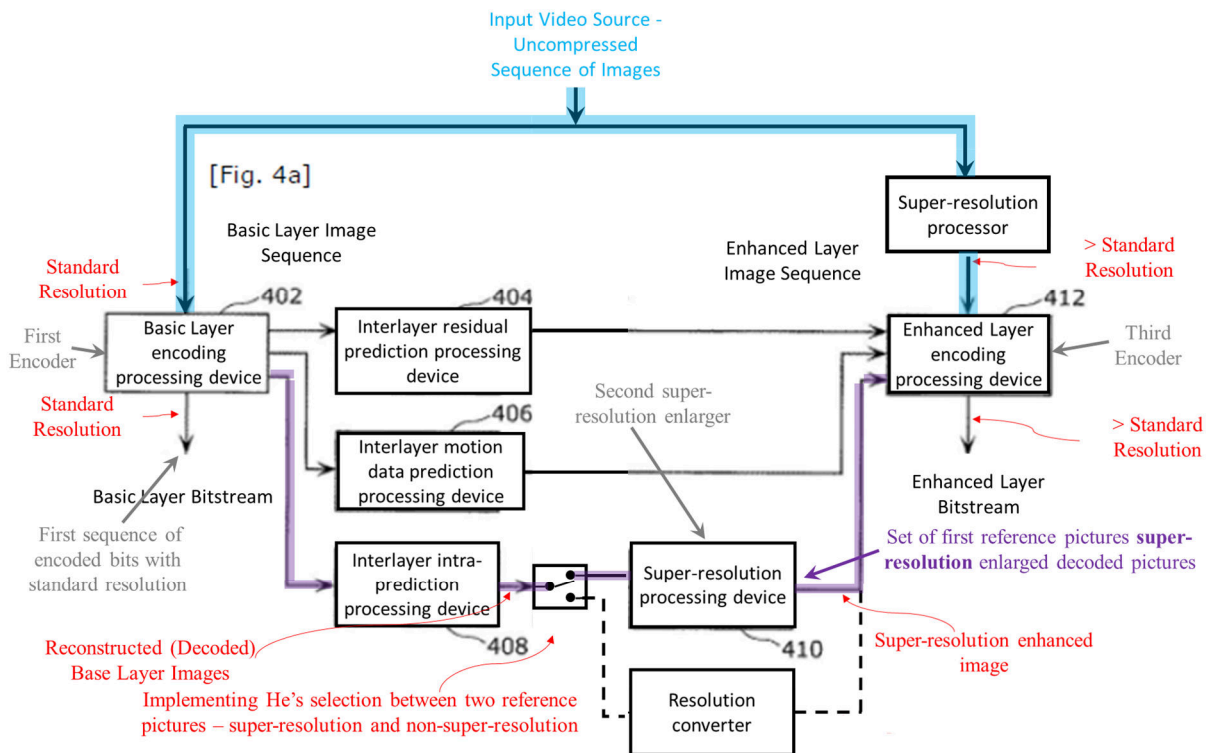
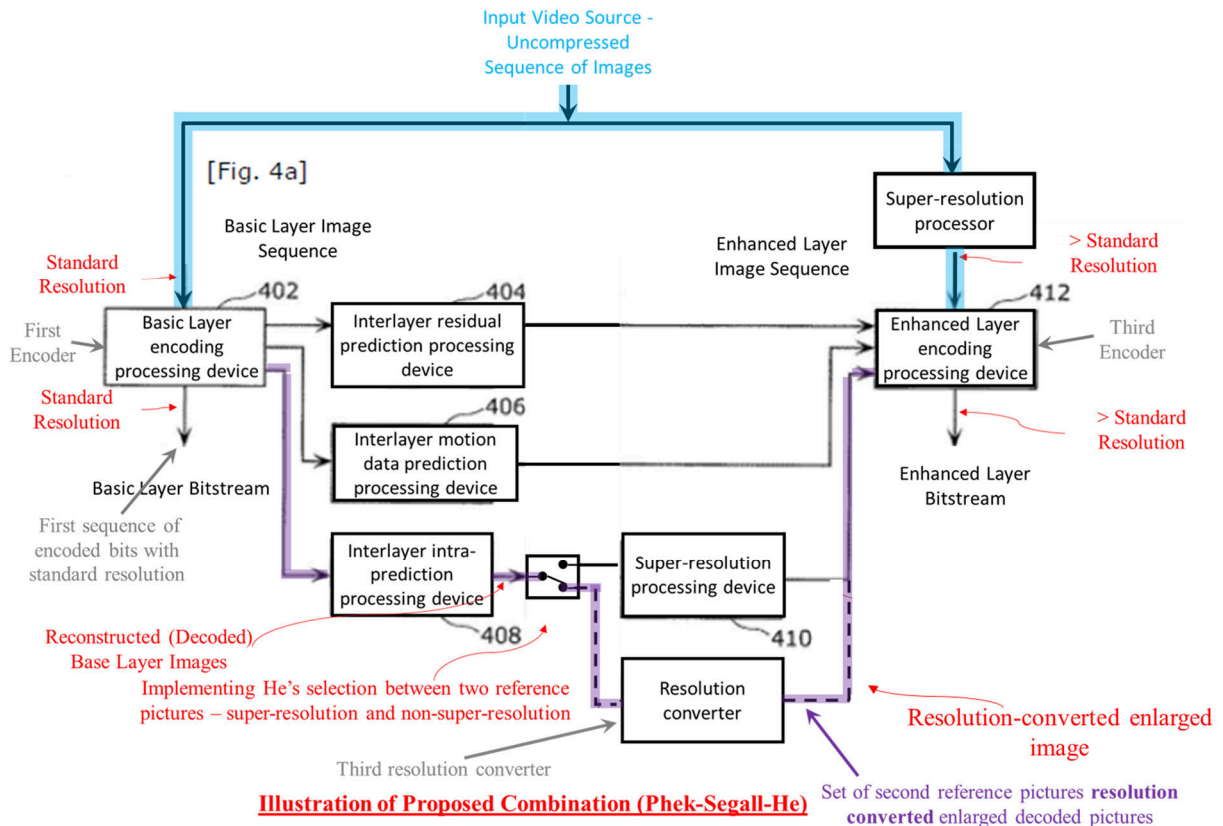


**Illustration of Proposed Combination (Phek-Segall-He) –
Selection of set of super-resolution reference pictures**

78. The following figure illustrates an example implementation of the proposed Phek-Segall-He combination in which the selection switch is configured

to select a set of reference pictures that have undergone conventional resolution conversion for enlargement:



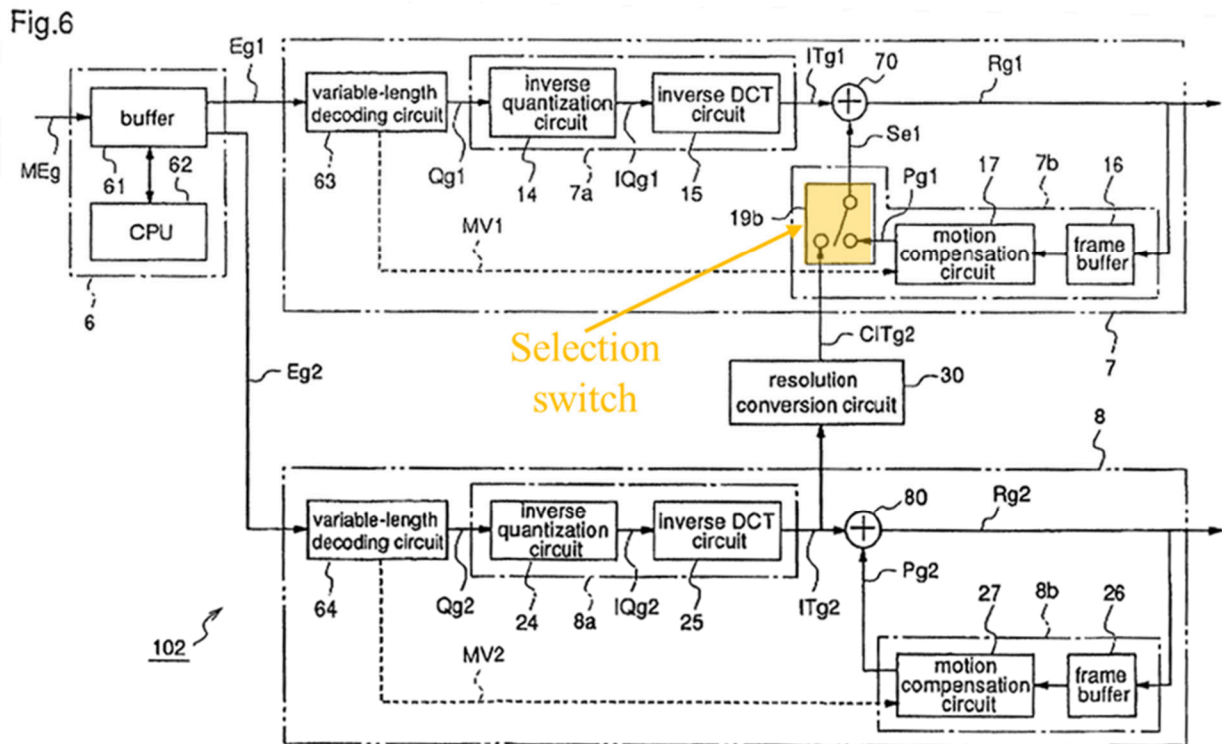
IX. Ground 1B – Obviousness based on Phek-Segall-He-Takahashi

A. Overview of Takahashi

79. Like the '448 Patent, Takahashi discloses a hierarchical image coding system configured to code digital image signals across multiple resolutions. APPLE-1046, [0001], Abstract. Through hierarchical coding, Takahashi enables simultaneous transmission of high-definition and standard-definition coded video data within a single bitstream, thereby supporting resolution-scalable transmission and decoding. APPLE-1046, [0004]. Although Takahashi describes a switching

mechanism in the context of decoding, a POSITA would have understood that the same switching principles are equally applicable to the encoding process. Takahashi's teachings regarding selection between reference picture sets based on resolution and coding efficiency are not limited to the decoding architecture and would have been readily recognized by a POSITA as symmetrical and transferable to the encoder-side operations to maintain consistency and optimize predictive coding performance.

80. Takahashi's coding device includes a selection switch 19b within a first decoding unit 7 that selects between different reference picture signals based on criteria bearing on compression and computational efficiency, such as the coding mode of the frame. APPLE-1046, [0131], [0176], Fig. 6. For example, in some embodiments, for I-frames, the switch selects resolution-converted data from a second decoding unit 8 as a reference picture signal, whereas for P- or B-frames, the switch selects high-resolution reference picture data from decoding unit 7. APPLE-1046, [0137]-[0140]. As illustrated in FIG. 6, selection switch 19b selects either regenerated resolution-converted data (CITg2) or predicted data (Pg1), depending on the coding mode. APPLE-1046, [0176], [0251].



Takahashi, FIG. 6 (annotated) showing selection switch 19b selecting between reference signals based on coding mode.

81. Takahashi explains that the pixel (or information) densities of high- and low-resolution reference pictures differ significantly, thereby warranting selection of different reference pictures to promote efficient processing. APPLE-1046, [0139]-[0140]. The implementation of reference picture selection across multiple embodiments – through components such as switches 19a, 19b, 29a, and 29b, as illustrated in FIGs. 1, 6, 12, and 15, respectively – demonstrates that reference picture selection was a foundational concept in Takahashi’s hierarchical coding system. APPLE-1046, [0131]-[0137], [0176], [0229]-[0235], [0253], [0262].

B. Combination of Phek, Segall, He, and Takahashi

82. As noted above, Phek describes a hierarchical coding system with super-resolution processing, while Segall and He describe similar scalable coding techniques that use interlayer prediction to reduce coding redundancies between a base layer and one or more enhancement layers. Takahashi describes analogous techniques and offers a complementary solution designed to reduce “the amount of operational processing” while maintaining efficient coding through “simple circuit configuration.” APPLE-1046, [0001], [0039], [0042]-[0045]. For example, Takahashi discloses an enhancement layer coding unit that selects between resolution-converted data from a lower layer or predicted data from the enhancement layer for use as a reference signal for the prediction of a frame in the enhancement layer based on a coding mode (e.g., whether the frame is an intra-coded I-frame or an inter-predicted B- or P-frame). APPLE-1046, [0131], [0139]-[0142], [0176], [0253], [0262], FIG. 6; *see also id.*, [0131]-[0137], [0176], [0189], [0229]-[0235], [0253], [0262]. A POSITA would have found it obvious to implement the hierarchical coder of the Phek-Segall-He combination further in accordance with Takahashi’s teaching to select between resolution-converted reference data or enhancement layer reference data based on coding mode. Multiple reasons would have prompted a POSITA to implement a Phek-Segall-He-Takahashi combination in this manner. *Id.*

83. First, for example, Takahashi's reference picture selection framework provides improved efficiency through simplified architecture. By implementing the selective reference signal approach, "the configuration ... becomes simpler" because resolution conversion or super-resolution enlargement of decoded base layer pictures will be unnecessary where the coding mode indicates that an enhancement layer picture can be used as a reference. APPLE-1046, [0042], [0141], [0219], [0282]-[0283].

84. Second, the implementation reduces computational complexity by providing a clear mechanism to choose between different reference signals, eliminating unnecessary processing operations during the decoding process. APPLE-1046, [0190]-[0192]. *See also*, APPLE-1046, [0001], [0039]-[0045], [0055], [0063]-[0066], [0192], [0204], [0213]-[0219], [0266].

85. Third, Takahashi's reference picture selection capability improves memory bandwidth management—a critical consideration in video coding systems. By streamlining the reference selection process, Takahashi's approach reduces unnecessary memory accesses, which would be particularly valuable in the context of the Phek-Segall combination. APPLE-1046, [0191]-[0192], [0213]-[0219].

86. Fourth, Takahashi's reference picture selection capability improves processing and compression efficiency. For example, Takahashi explains that "since an image signal corresponding to the I frame is not subjected to temporal prediction,

for the I frame, predictive coding in which the low-resolution regenerated data corresponding to the target processing signal is used as predicted data is more efficient than the processing in which the target processing signal of the I frame is coded as it is. However, for other frames, even when the image signal having a different resolution is not used as predicted data, the compression efficiency is not reduced much compared with the case that all image signals are subjected to predictive coding.” APPLE-1046, [0140]; *see also id.* [0138]-[0142].

87. Fifth, a POSITA would have recognized that implementing Takahashi’s selection switch simplifies hardware requirements while maintaining decompression efficiency. Takahashi expressly teaches the “reduc[ti]on of [the] amount of operation and simplifying the configuration of the hierarchical decoding apparatus.” APPLE-1046, [0047].

88. Sixth, a POSITA would have found it obvious to apply Takahashi’s suggestion for selecting reference pictures based on coding mode because doing so merely entails the predictable use of a known technique as taught by Takahashi to a similar scalable coding system as taught by Phek to achieve predictable results. Here, Takahashi expressly describes how to perform reference picture selection in a scalable coding system based on coding mode and the implementation of such techniques was well within the capability of a POSITA. A POSITA would have reasonably expected success, especially since reference picture selection techniques

like those described in Takahashi were commonly implemented before the Critical Date. *Id.*

C. Analysis

89. Based on my review, the Phek-Segall-He-Takahashi combination would have rendered claims 1-3 of the '448 Patent obvious for each of the reasons described in the Petition.

X. Ground 1C – Obviousness based on Phek-Segall-Takahashi

90. Grounds 1A and 1B rely on He's teachings directed to selective application of reference picture enhancements in a scalable coding system. In the context of the combinations addressed above, He's teachings as applied to the Phek-Segall system would have rendered obvious the features recited in [1.7], [2.6], and [3.6]. However, as further described in Ground 1B, the application of Takahashi's teachings related to reference picture selection based on coding mode to the Phek-Segall system provides an additional and independent basis for rendering obvious [1.7], [2.6], and [3.6]. Accordingly, even if He's teachings were part of the combination, a Phek-Segall-Takahashi combination would have rendered obvious all claims 1-3 of the '448 Patent and their respective limitations for the reasons addressed above in Grounds 1A-1B without reference to He's teachings. Additionally, since neither claims 2 nor 3 require *both* a second super-resolution enlarger *and* a third resolution converter (claim 2 recites only the latter and claim 3

the former), a system with only *one* of these devices in the Phek-Segall-Takahashi combination would suffice to address claims 2 and 3, and He's selection capability would be inapplicable when only one of the second super-resolution enlarger and the third resolution converter is implemented.

XI. Ground 1D – Obviousness based on Phek-Takahashi

91. Grounds 1A and 1B rely on He's teachings directed to selective application of reference picture enhancements in a scalable coding system. In the context of the combinations addressed above, He's teachings as applied to the Phek-Segall system would have rendered obvious the features recited in [3.6]. However, as further described in Ground 1B, the application of Takahashi's teachings related to reference picture selection based on coding mode to Phek's system provides an additional and independent basis for rendering obvious [3.6]. Additionally, since claim 3 does not require *both* a second super-resolution enlarger *and* a third resolution converter, and instead requires only a second super-resolution enlarger (regardless of whether the system further includes a third resolution converter), a system with only a second super-resolution enlarger suffices to meet claim 3, and neither Segall's nor He's teachings are necessary to provide a third resolution converter or a selection capability between the output of a second super-resolution enlarger and a third resolution converter. Accordingly, even if He's and Segall's teachings were not considered, a Phek-Takahashi combination alone would have

rendered obvious claim 3 and each of its limitations for the reasons addressed above in Grounds 1A and 1B with reference to the teachings of Phek and Takahashi alone.

XII. Additional Remarks

92. I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

APPENDIX A

Expert Witness, CTO

Technology industry veteran with electronics/software/hardware/video/audio/data expertise.

IoT | Consumer Electronics | Telecommunications | Cable | Satellite | Broadband | Wireless

- Expert witness testimony (PTAB, ITC), technical consulting, and expert reports for renowned patent law firms such as Fish & Richardson and Banner Witcoff.
- 117 Patents and Patent publications. Served on corporate patent boards and as 30(b)(6) witness.
- Uniquely broad hardware/software/systems technical understanding.
- Award winning design and development including Best of Show, Technology Emmy, and Best of Innovations of over 100 million shipped products, responsible for \$1.3B annual revenue.
- Industries: Consumer Electronics, Cable, Satellite, Internet of Things (IoT), Telematics, Smart Truck Logistics, Transportation, Alarm Systems, Smart Tank monitoring & fulfillment, Smart Home, Television, Telecommunications, Video, Audio, Wireless, Broadband, OTT Video, IPTV, Payments
- Technical: hardware design, software design, systems design, mechanical design, embedded systems, cloud computing, AWS, Azure, Oracle Cloud Infrastructure (OCI), SaaS, edge computing, high speed digital, C, Java, Python, Linux, mobile applications (iOS, Android, cross-platform), web applications (Java, JavaScript, HTML), firmware, RTOS, user interfaces, UI/UX, video, audio, data, RF, DSP, communications, cybersecurity, encryption, error correction coding, real-time systems, cable, CATV, DOCSIS, broadband, satellite, satcom, IPTV, OTT video, video streaming, image processing, wireless, cellular, 3G, 4G, LTE, LTE-M, 5G, NB-IoT, Cat-M1, WiFi, ZigBee, Z-Wave, Bluetooth, BLE, LoRa, Internet of Things (IoT), IIoT, sensors, Machine-to-Machine (M2M), Telematics, AI, ML, networks, payments, consumer electronics, and telecommunications.

EXPERIENCE

Nov. 2016-present, **Expert Witness/CTO**, Independent Consultant

Technology, product development, organizational, & intellectual property consulting

- Expert Witness Reports and Testimony - Declarations, Opinions, PTAB Inter Partes Review (IPR) Petitions and Defense, Depositions
- Intellectual Property/Patent assistance, prosecution/defense strategy, search
- Technical Consulting

Jul. 2019 – June 2022, **Chief Technology Officer (CTO)**, **Telular**, an Ametek Company, Greater Atlanta Area

- Responsible for global engineering, corporate technical strategy, and technical representation.
- Developed SaaS, mobile, and hardware products for Industrial IoT (IIoT) businesses including transportation, tank monitoring, petroleum logistics, and facility alarm monitoring with 1.4M+ subscribers, sold under the SkyBitz and Telguard brands.
- Led the development of an IoT Toolkit (scalable platform and APIs) to extend the Telular IoT platform for all 60+ (and growing) AMETEK companies, enabling development of high- value IIoT recurring revenue web and mobile applications.
- SaaS, Cellular, 3G, 4G, LTE, LTE-M, 5G, NB-IoT, Cat-M1, BLE, Satellite, cloud, distributed systems, Azure, Oracle Cloud, IoT, telematics, AI, ML, M2M, hardware, GPS, solar, low-power design, broadband, firmware, software, systems, architecture, video, image processing, mobile apps, web apps.

Aug. 2011 – Oct. 2016, **Vice President of Engineering, Head of the Atlanta R & D Center, EchoStar Technologies**, Greater Atlanta Area (\$3B revenue, Engineering for Dish Network with a common controlling stockholder)

- Developed products for Dish Network and international customers including highest volume set-top boxes, H.265, HEVC, 3D, Satellite, MoCA, transcoding, Embedded C Linux applications, mobile applications (iOS and Android), SaaS, and web applications (Javascript, HTML). Provided product lifecycle support of contract manufacturers, test methodologies, customer service, QA, marketing, and sales.

- Led the architecture and global development of a huge end-to-end secure IoT cloud/fog/edge Platform for the consumer security & smart home market and other adjacent markets. Established the unique TV and mobile UI and MyLocal911 patented self-monitored security paradigm. System architecture consisted of 32 cloud systems and 24 CPE products. Systems included BSS/OSS, AWS cloud storage, 2-way video/audio streaming, authentication, provisioning, software download, command and control, customer service, online storefront, 911 emergency VoIP, logistics, CPE, and mobile applications. Represented the platform at trade shows.
- Functioned as a general manager in roles and responsibilities including vision, operations, business results, product management, program management, complex projects and services, hardware/software/systems product development of video, Internet of Things (IoT), and mobile application products.
- **Winner of the prestigious Best of Show award at the 2013 CES for the Hopper** because of the Hopper Transfers functionality and mobile applications.
- **Won 2015 CSI award “Best smart home product, technology or service”.**

Aug. 1990 – July 2011, **Vice President of Engineering, Cisco / Scientific Atlanta**, Greater Atlanta Area (\$35B / \$1.9B revenue companies respectively. Cisco acquired Scientific Atlanta Feb. 2006)

- Intellectual property – served on the corporate patent board, provided patent assistance, and testified in patent litigation cases including as a 30(b)(6) witness representing the corporation.
- Responsible for the hardware/firmware/software/mechanical/systems/architecture/ASIC requirements design and development of several generations of high volume set top boxes and other products with extensive data communications and multimedia capabilities and advanced features including DOCSIS 1/2/3 and hybrid gateways, 802.11, IPTV, DVR, cable modems, ADSL, VDSL, DVB-T/C/S, bootloaders, factory diagnostics, application frameworks, Nagra, DRMs, conditional access, secure microprocessors, device management, Android, Adobe Flash, Linux, DVD play/record, MPEG-4, MPEG-2, H.264, NTSC, PAL, DAVIC, MoCA, high-performance CPUs, cablecards, network processors, HDMI, multiple video/audio display interfaces, 2D/3D graphics, multiple RF tuners, and full spectrum tuners.
- Products developed supported worldwide video, audio, power supply, and regulatory standards.
- Developed products manufactured in company factories, contract manufacturers (CMs), Original Design Manufacturers (ODMs), and Joint Design Manufacturers (JDMs).
- Developed processes and practices to ensure success in high quality, high volume, low cost, and fast time-to-market product development.
- Architected Video-On-Demand (VOD) systems.
- Architected robust software download system to ensure network disaster recovery to avoid truck rolls. Received some of the **industries’ first downloadable software patents and an electronic program guide patent**. Developed the downloadable software system, enabling the applications software development business which evolved into a major corporate strategic business objective.
- Responsible for the total value proposition strategy internally in the organization through process design and externally facing customers to propose innovative solutions that add value and differentiate our offering.
- Established and managed department capex and opex budgets and manpower planning.
- Achieved unprecedented 3%/qtr product cost reductions for all products during the product lifecycle.
- Highly reliable products never had a field recall, which would have been disastrous to the business due to truck roll costs.
- Established software development department and software development practices including software processes, code reviews, networked version control and defect tracking, unit test teams, coding standards, and release processes.
- Reduced product development time to market for set top boxes from 14 months to 6 months through continuous process improvement
- Scaled organization from supporting \$10M to \$1.3B in sales
- Accounted for more than **70% of the revenues for Cisco’s Service Provider Video Technology Group and for Scientific Atlanta Corporation**.
- Award winning design and development of over 100 million shipped products
- **Winner of Technology Emmy in 2012 for Pioneering Development of Multi-Room DVR.**

- **Winner of 2006 CES "Best of Innovations" award for DVR/DVD Recorder/Player.**
- **Winner of Motorola/EE Times Excellence in Innovation Award** in 1994.

Nov. 1985 - July 1990, **Hardware Engineering Manager / Senior Engineer, Wegener Communications, Inc.,** Greater Atlanta Area

- Managed product development of video, audio, and data satellite receivers, modulators, graphics display systems, DSP-based companders, FSK and PSK satellite modems, multiplexers, forward error correction (FEC) codecs, RF upconverters and downconverters, and baseband analog and digital processing components. Disciplines managed included hardware, ASICs, FPGAs, RF, digital, microprocessors, analog, mechanical, and embedded software.
- Architected and designed forward error correction (FEC) coding systems, PSK modems, and analog control systems for RF modulators and PSK demodulators.

Mar. 1983 - June 1985 (while working at Scientific Atlanta), Assistant Professor, **DeVry Institute of Technology,** Greater Atlanta Area

- Taught evening school courses in microprocessor hardware/software and Electronics

June 1982 – Oct. 1985, **Scientific-Atlanta, Engineer II/Engineer I,** Greater Atlanta Area

- Designed software and hardware including addressable data transmitters, video sync suppression scramblers, transaction format converters, and data channel monitors for addressable Cable Television systems and Set Top Boxes.

EDUCATION

- MSEE course work in Electrical Engineering, Georgia Institute of Technology, Atlanta, Georgia
- BSEE, University of Tennessee, Knoxville, Tennessee, with High Honors. Specialization in Computer Engineering. GPA: 3.53/4.00.
- Georgia Institute of Technology Scrum Leadership Certificate, Certified Scrum Master (CSM), Certified Scrum Product Owner (CSPO), Certified Large Scale Scrum (LeSS) Practitioner
- Many short courses in business and engineering.