

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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INTEL CORPORATION,

Petitioner

v.

INTERDIGITAL, INC.,

Patent Owner

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Case: IPR2024-01441

U.S. Patent No. 9,674,556

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**DECLARATION OF DR. IAIN RICHARDSON**

**Declaration**

I declare that all statements made herein 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: 30 January 2025

By: 

Iain Richardson, Ph.D.

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I, Dr. Iain Richardson, do hereby declare:

## **I. INTRODUCTION**

1. My name is Dr. Iain Richardson, and I have been retained as a technical expert by counsel for Interdigital, Inc. (“Interdigital”), who I understand is the Patent Owner in the present proceeding. I also understand that Intel Corporation (“Intel”) is the Petitioner in the current proceeding.

2. I have been asked by counsel for InterDigital to provide my opinion as to certain issues raised by Petitioners in a petition for inter partes review (“Petition”) of U.S. Patent No. 9,674,556 (“the ’556 Patent”). I have also been asked to consider the state of the art and various references available before the effective filing date of the ’556 Patent. I submit this Declaration in support of InterDigital’s Preliminary Response to the Petition. Unless otherwise stated, the matters contained in this report are of my own personal knowledge and, if called as a witness, I could and would testify competently and truthfully with regard to the matters set forth herein.

3. The scope of this Declaration is limited to certain statements and positions taken in the Petition and the accompanying Declaration of Dr. Clifford Reader. Accordingly, the fact that I may not opine on a particular position taken in the Petition should not be construed as agreement with any such position.

4. My company Vcodex BV is being compensated at the rate of \$1,000 per hour for my work in this case. Neither Vcodex BVs compensation nor any personal remuneration I receive from my company Vcodex BV or from my company Vcodex Ltd. is tied in any way to the outcome of this proceeding or the content of my testimony.

## **II. QUALIFICATIONS**

5. I have summarized in this section my educational background, work experience, and other relevant qualifications. A true and correct copy of my curriculum vitae is submitted as Exhibit 2002.

6. Below, I have summarized in this section my educational background, career history and other relevant qualifications.

7. I am Director and co-founder of Vcodex BV and Vcodex Ltd. I am an internationally recognized expert on video and image compression coding with over 30 years of experience in the field of video, image, multimedia, and general-purpose data encoding, decoding, compression, decompression, and transmission.

8. I obtained a Masters of Engineering from Heriot-Watt University, Edinburgh, UK, in 1990. I received a Doctor of Philosophy (Ph.D.) in video compression coding from Robert Gordon University, Aberdeen, UK in 1999. I served as a full professor at Robert Gordon University for 17 years, where I taught undergraduate and graduate engineering courses on topics, including signal

processing, communications engineering, image and video processing, and multimedia compression.

9. In 1993, I assumed a post as a Lecturer, then Reader and eventually a Full Professor in the field of image and video compression in the School of Engineering at Robert Gordon University. In 2009, I was awarded the position of Honorary Professor with the Robert Gordon University.

10. I am the author of five books and over 70 journal and conference papers on video compression, including two widely cited books on the H.264/MPEG-4 standards and a book focusing on the H.265/HEVC standard. I am regularly invited to give lectures on video compression coding, including at the Smithsonian Institution and the US Patent and Trademark Office.

11. I am a former member of British Standards Institute expert group IST/37, the committee which represents the UK in ISO/IEC MPEG standardization. I am currently a member of NEN, the Netherlands equivalent group.

12. I have many years of experience in researching, developing and implementing video compression codecs in software and hardware. In 1995, during my employment at Robert Gordon University, I co-founded and became Technical Director, equivalent of Chief Technology Officer, at 4i2i Communications Limited. I held this position until 2000. In my role at 4i2i, I was responsible for and engaged in the design of software and hardware modules for compression and communication

systems, including the design of video processing algorithms in software and hardware for implementation on processing devices and the design of compression algorithms such as block-based transforms, run-length coding and variable-length coding in software and hardware. A modified version of one of my video compression hardware designs was successfully used by NASA to stream video from the International Space Station.

13. In 2007, I founded Vcodex Limited and currently serve as the CEO, through which I provide technical and strategic advice to technology companies particularly relating to video, image, and data compression for streaming.

14. In 2009, I founded Onecodec Limited and served as CEO, leading the company's development of innovative video, image, and multimedia data compression and storage software and systems. Onecodec's technology and business activities were merged with Vcodex Limited in 2015, and Vcodex B.V. in 2019.

15. I am a named inventor on 11 patents or patent applications, including U.S. and non-US patents and applications.

### **III. MATERIALS CONSIDERED**

16. My opinions are based on my years of education, research, and experience, as well as my investigation and study of the relevant materials. In reaching the conclusions described in this Declaration, I have considered the references and exhibits referenced in this Declaration, as well as the Petition in this

proceeding and the exhibits cited in the Petition, including in particular the Petition and the Declaration of Petitioner's expert, Dr. Clifford Reader (EX1003). I have also considered the following documents:

- a) Intel's Petition challenging Claims 1-8 of the '556 Patent (Paper 2)
- b) U.S. Patent No. 9,674,556 ("the '556 Patent") (EX1001)
- c) Prosecution History of the '556 Patent (EX1002)
- d) Prosecution History of U.S. Patent Application Publication No. 12/312,386, filed as PCT/US2007/22795 ("the '386 Application") (EX1005)
- e) U.S. Patent Appl. Publ. No. 2003/0219073 ("Lee") (EX1006)
- f) U.S. Patent Appl. Publ. No. 2006/0110062 ("Chiang") (EX1007)
- g) U.S. Patent Publication No. 2003/0152146 ("Lin") (EX1008)
- h) SMPTE Standard: VC-1 Compressed Video Bitstream Format and Decoding Process, SMPTE 421M-2006 ("VC1 Standard") (EX1009)
- i) Onur G. Guleryuz, A Nonlinear Loop Filter for Quantization Noise Removal in Hybrid Video Compression, IEEE Int'l Conference on Image Processing, 2005 (EX1010)
- j) U.S. Patent No. 8,194,757 to Schoner (EX1011)
- k) U.S. Patent No. 6,360,024 to Tan (EX1012)
- l) U.S. Patent No. 1,796,030 to Kell (EX1013)

- m) Xin Li & Michael T. Orchard, Spatially adaptive image denoising under overcomplete expansion, Proc. ICIP, Vol. 3, Sep. 2000 (EX1014)
- n) ISO/IEC/JTC1/SC2/WG8 Moving Picture Expert Group, MPEG 89/254, Adaptive filter in the coding loop, Jan. 1990 (EX1015)
- o) CCITT SGXV Working Party XV/1 Specialists Group on Coding for Visual Telephony, #356, Loop Filter Improvement, Sept. 19, 1988 (EX1016)
- p) Declaration of June Ann Munford (EX1017)
- q) Bojnordi M.N. et al, A Fast Two Dimensional Deblocking Filter for H.264/AVC Video Coding, IEEE CCECE/CCGEI, May 2006 (EX1018)
- r) U.S. Patent Appl. Publ. No. 2007/0286290 (“Leung”) (EX1021)
- s) Warrington S, High Throughput Architectures for Variable Block Size Motion Estimation, Queen’s University, Sept. 2006 (EX1022)
- t) Excerpts from the SMPTE Motion Imaging Journal, May/June 2006 (EX1023)
- u) ’556 Patent Infringement Contention Claim Chart, Exhibit 18 to InterDigital’s First Suppl. Responses to Respondents’ First Set of Interrogatories in ITC-337-TA-1373 (EX1024)
- v) Commission Investigative Staff’s Markman Brief, ITC-337-TA-1373 (EX1025)

- w) U.S. Patent No. 7,388,999 (“Samadani”) (EX1026)
- x) ISO/IEC/JTC1/SG2/WG8 Moving Picture Expert Group MPEG 89/248 (EX1027)
- y) Reader C, Intraframe and Interframe Adaptive Transform Coding, SPIE Vol. 66, 1975 (EX1028)
- z) Reader C, MPEG4- Coding for Content, Interactivity, and Universal Accessibility (EX1029)
- aa) MPEG Video Compression Standard, Edited by J.L. Mitchell et al, Chapter 16 (EX1030)
- bb) ’556 Patent Infringement Contention Claim Chart, Exhibit 5 to InterDigital’s Infringement Contentions in InterDigital et al. v. Lenovo Group Ltd. et al., no. 5:23-cv-00493-FL (E.D.N.C.) (EX1031)
- cc) Respondents’ Opening Markman Brief, ITC-337-TA-1373 (EX1032)
- dd) Corrected Complainant’s Opening Markman Brief, ITC-337-TA-1373 (EX1033)
- ee) Public Version of Complainants’ Initial Post-Hearing Brief (EX2003)

#### **IV. PRIORITY DATE FOR ’556 PATENT**

17. I have not been asked to give an opinion as to the priority date of the ’556 Patent.

18. I understand that Petitioner's expert, Dr. Reader, asserts that the priority date is November 8, 2006. For the purposes of my analysis, I have assumed that this is the priority date of the '556 Patent.

## **V. LEVEL OF ORDINARY SKILL IN THE ART**

19. I understand that Dr. Reader asserts that a Person of Ordinary Skill in the Art ("POSITA") as of the priority date of the '556 Patent would have had "at least a bachelor's degree in electrical engineering, computer science, computer engineering, or a related field, and approximately three years of experience in design, development, and/or testing of relevant multimedia processing, such as video, and/or image processing or coding. Advanced graduate studies with coursework and/or research focusing on topics of video encoding and decoding could substitute for working experience in the field." EX1003, ¶93.

20. For the purposes of my analysis, I assume that a POSITA as of the priority date of the '556 Patent would have had this level of skill.

21. Based on this standard, I am a person of at least ordinary skill in the art and was so at the time of the invention of the '556 Patent.

## **VI. LEGAL STANDARDS**

22. For purposes of this Declaration, I use the legal principles below as a guide in formulating my opinions. I am not an attorney, and I am not offering any

opinions regarding legal matters; however, I understand the following legal principles relevant to the issues herein.

**A. Claim Construction**

23. I understand that the claims of a patent define the claimed invention. I understand the first step in determining whether or not a patent claim is valid is to properly construe the claims.

24. I further understand that claim construction in an *Inter Partes* Review (IPR) proceeding is a legal question for the Patent Trial and Appeal Board (PTAB or Board) to decide. In general, I understand that claim terms are to be given their ordinary and customary meaning to a POSITA in the context of the patent at the time the patent was filed.

25. I understand that a POSITA is deemed to read the claims in the context of the entire patent, including the specification and prosecution history which is referred to as the intrinsic record. In other words, the terms are not considered in a vacuum. While the intrinsic record may inform the construction of a claim term, one must be careful not to read words into the claims from the specification and preferred embodiments as the language of the claims controls.

26. I understand that the meaning of the claim terms will depart from their ordinary and customary meaning only when the patentee has acted as its own

lexicographer (e.g., provided its own special meaning to a term) or clearly and unmistakably disavowed or disclaimed any claim scope.

27. I understand that reference materials that were publicly available at the time that the patent application was filed, such as dictionaries, treatises or other technical references, may provide context and background for deciphering how one of ordinary skill in the art would have considered the terms used in the claims. However, I understand that such references, as well as testimony are generally known as “extrinsic evidence,” and are accorded less weight than evidence found within the patent and prosecution history. In addition, I understand that extrinsic evidence that is inconsistent with the claims, specification, or prosecution history should not be considered in the claim construction process.

#### **B. Obviousness**

28. I further understand that a claimed invention is not patentable under 35 U.S.C. §103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. Obviousness, as I understand it, is based on the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and secondary indicia of obviousness to the extent they exist.

29. I understand that whether there are any relevant differences between the prior art and the claimed invention is to be analyzed from the view of a POSITA at the time of the invention. A POSITA is a hypothetical person who is presumed to be aware of all of the relevant art at the time of the invention. The POSITA is not an automaton, and may be able to fit together the teachings of multiple patents employing ordinary creativity and the common sense that familiar items may have obvious uses in another context or beyond their primary purposes.

30. I understand that an obviousness determination requires finding that a POSITA would have been motivated to combine or modify the teachings in the prior art and would have had a reasonable expectation of success in doing so. I further understand that this requires showing a reason that would have prompted a POSITA in the relevant field to combine the elements in the way the claimed new invention does.

31. I understand that obviousness of a patent claim cannot properly be established through hindsight, and that elements from different prior art references, or different embodiments of a single prior art reference, cannot be selected to create the claimed invention using the invention itself as a roadmap. I understand that the claimed invention as a whole must be compared to the prior art as a whole, and courts must avoid aggregating pieces of prior art through hindsight that would not have been combined absent the inventors' insight.

### **C. Motivation to Combine**

32. I understand that it is appropriate to look to a variety of factors when evaluating reasons to combine references in an obviousness analysis, and that it is important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the prior art elements in the manner claimed. I understand that a patent composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. I also understand that this is so because inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known.

33. I understand that it is not enough to show obviousness merely by showing that the references were capable of combination without a suggestion of the desirability of the modification. In addition, I understand that a challenger asserting that a POSITA would have combined references must demonstrate that the skilled artisan would have had a reasonable expectation of success in doing so.

34. I understand many circumstances arise in which a combination or other modification of the disclosure of prior art references may not prevent patentability on obviousness grounds, including: improper hindsight reconstruction, unpredictable results of the combination or modification, no reasonable likelihood of success, the elements from the prior art could not have been combined or modified

in the way claimed without undue experimentation, the combination or modification of elements would not have been obvious to try, the combination or modification would change the principle of the prior art's operation or render it unsuitable for its stated purpose, if the combination or modification would be seemingly inoperable, the prior art does not identify the problem solved by the invention, the invention went against the accepted wisdom in the field, one or more references teach away from the proposed combination or modification, or where the teachings of the prior art would have been substituted rather than combined.

## **VII. SCOPE OF OPINIONS**

35. I set forth my opinions throughout this Declaration.

36. It is my opinion that the Challenged Claims of the '556 Patent are not obvious in view of any of the asserted references, alone or in combination, as discussed in this Declaration.

37. I have reviewed the Petition and the associated Declaration of Dr. Clifford Reader (EX1003) and disagree with many of the assertions made therein. However, for the purposes of my analysis, I only opine on certain positions taken by Petitioner and Dr. Reader as I explain in more detail below. If I do not explicitly address a certain position or opinion, this does not indicate that I agree with any such position or opinion.

38. It is my opinion that the issues discussed in this Declaration sufficiently demonstrate that the Challenged Claims are not obvious under any of the Petition's asserted grounds.

## **VIII. CLAIM CONSTRUCTION**

39. In general, for my analysis, I have applied the plain and ordinary meaning of claim terms as a POSITA would have understood those terms as of the priority date of the '556 Patent.

40. I understand that Dr. Reader purportedly identifies four different constructions for the "sparse de-noising filter" term: (1) ITC Respondent's "alternative construction" ("a filter which exploits a sparse image model using an over complete set of linear transforms and hard thresh-holding, which is not a deringing filter"); (2) ITC Respondent's primary construction ("sparse de-noising filter for performing a second pass to reduce noise; which is not a deringing filter"); (3) ITC Staff's construction ("a filter that reduces noise based on a sparse representation of the signal"); and (4) a "PO's proposed ITC construction." Construction (4) is worded identically to (3) ITC Staff's construction. Dr. Reader, however, rewrites construction (4) as "the filter 'reduces noise based on a sparse representation of the signal' and a 'sparse representation of the signal' encompasses a sparse signal." Reader, ¶¶128 (citing EXs1025, 1032-33), 129, 132. Dr. Reader

later characterizes construction (4) as “incorrect.” *Id.* I specifically address these four constructions identified by Dr. Reader below.

**A. Dr. Reader Misinterprets InterDigital’s ITC Construction of “sparse de-noising filter”**

41. I understand that Dr. Reader alleges obviousness for Grounds 1A and 2 based only on his interpretation of InterDigital’s construction of the term “sparse de-noising filter” in the ITC proceeding. Reader, ¶¶137 (discussing Ground 1A), 218 (discussing Ground 2). In my opinion, Dr Reader misinterprets InterDigital’s construction of this term, as I explain below.

42. InterDigital and ITC Staff proposed the same construction for the “sparse de-noising filter” in the previously pending ITC proceeding. *See* EX1025; EX1032; EX1033. Notwithstanding this identical language, Dr. Reader claims InterDigital’s and Staff’s constructions are different by alleging “the dispute is whether PO’s interpretation, which encompasses sparse signals as well as sparse representations of signals. . . is correct” and that he “understand[s] there is a dispute whether the construction encompasses that the signal itself is sparse, or whether just the representation of the signal is sparse.” Reader, ¶129. Dr. Reader’s misstatement of InterDigital’s construction reads the “sparse representation of the signal” requirement out of the construction (something InterDigital did not propose) and broadens the construction to encompass any filter that acts on “a sparse signal,” regardless of the filter’s actual design or operation. *See* Reader, ¶¶129, 132. A

POSITA would not have understood that the requirement for “a filter that reduces noise based on a sparse representation of the signal” in the context and time of the ’556 Patent, would be satisfied by any filter that acts on “a sparse signal,” regardless of the filter’s actual design or operation. As I explain in detail below, this is true even if the input signal happens to be sparse when the filter acts upon it.

43. Applying this misinterpretation, Dr. Reader opines in Grounds 1A and 2 that the Lee and Chiang references, respectively, disclose the claimed “sparse de-noising filter” without showing either reference discloses a filter that “reduce[s] noise based on a sparse representation of the signal.” Instead, Dr. Reader reads the phrase “a sparse representation of the signal” out of InterDigital’s construction. Reader, ¶¶147-149, 228-229. In other words, Dr. Reader relies on a different construction in Ground 1A and 2 to the construction that InterDigital actually proposed and applied in the ITC. In my opinion, a POSITA would have understood that a filter must reduce noise based on a sparse representation of the signal as required by InterDigital’s actual construction, in order to be a “sparse de-noising filter.” ’556 Patent, 2:37-47 (explaining the relevance of the signal’s “sparse representation at the filtering stage”); 10:62-64, 11:16-24 (embodiment architecture would create sparse representation); 13:24-65 (two embodiment algorithms would create sparse representations); 14:19-21 (the adaptive sparse de-noising filter is directed to recovering the original signal from noise); Fig. 5; *see also* Reader, ¶65

(transform domain can represent the noise and the video frame data in the pixel domain), ¶105 (example of sparse filter operating in transform domain).<sup>1</sup>

44. In my view, a POSITA would have understood that a sparse denoising filter must reduce noise based on a sparse representation of the signal even if the signal input into the “sparse de-noising filter” happens to already be sparse. Conversely, a filter that reduces noise based on a sparse representation of the signal is not excluded from being a sparse de-noising filter just because it happens to operate on a signal that itself is sparse. As an analogy, consider a low-pass filter that reduces high frequency components of a signal. A low-pass filter remains a low-pass filter even if it happens to operate on a signal that does not contain any high frequency components.

45. The difference between InterDigital’s actual ITC construction (that a filter must reduce noise based on a sparse representation of the signal in order to be a “sparse de-noising filter”) and Dr. Reader’s interpretation of it is that, in my view, “a filter that reduces noise based on a sparse representation of the signal” is not satisfied by any filter merely because a sparse signal is input but rather requires a

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<sup>1</sup> Petitioner does not disagree with this, noting its position that “ITC Staff’s proposed construction, [“a filter that reduces noise based on a sparse representation of the signal”], . . . is actually consistent with Respondents’ alternative construction,” which is the construction that Petitioner says “should be adopted.” Petition, 16-17.

filter that reduces noise based on a sparse representation of an input signal being decoded, regardless of whether that signal was already sparse.

46. In my opinion, a suitable sparse representation is one where the signal and the noise can be discriminated from each other. The appropriate representation may depend on characteristics of both the signal and the noise.

47. Dr. Reader appears to agree that “a filter that reduces noise based on a sparse representation of the signal” is not satisfied by any arbitrary filter when he refers to sparse filters as those that can operate “to produce sparse decompositions of the pixel data.” Reader, ¶65. In my opinion, such decomposed pixel data refers to an example of a sparse representation of the signal. Reader, ¶65. Dr. Reader also acknowledges that a sparse filter can operate to “remove[] the low frequency coefficients, leaving only the image coefficients that are relatively ‘sparse’ as compared to the uniformly distributed noise coefficients.” *Id.* This is consistent with the effect of the “filtering operation” of a sparse denoising filter in which noise is removed or reduced based on the sparse representation of the signal. Here, Dr. Reader acknowledges that the “filtering operation” works to “remove” the low frequency coefficients (the noise) from the “sparse decompositions of the pixel data” (the sparse representation of the signal), which means that the sparse representation of the signal still included those low frequency or noisy coefficients prior to the

filtering operation. This is a critical distinction from Lee's edge map, as I will discuss below.

48. Manhattan's skyline can operate as a helpful analogy to understand sparse denoising filters. In this analogy, the signal is comprised of all the structures in Manhattan (skyscrapers and non-skyscraper buildings), which can be shown from a bird's eye view (left) as well as from a skyline perspective (right):



49. Here, the skyscrapers are the items of interest, akin to the true signal before being corrupted by noise due to lossy quantization during compression, and the other buildings are noise. If the task is to filter out the other buildings (reduce the noise) and leave the skyscrapers, the task of separating skyscrapers in the bird's eye image on the left would be difficult, whereas it would be much easier in the image on the right because the difference in perspective allows the skyscrapers to stand out from the many other lower-height buildings.

50. This helps inform the understanding of a sparse denoising filter, which reduces noise based on a sparse representation of the signal. A sparse

representation is a perspective of the input signal in which certain components of the signal can be more easily discriminated to separate the signal (before being corrupted by noise) from the noise. Importantly, a sparse representation must still represent the input data. In the Manhattan analogy, the skyline perspective can be considered a sparse representation because the items of interest (the skyscrapers) stand out from the rest, but we have not leveled any buildings in Manhattan and therefore all the information is still there, albeit represented in a different domain or perspective. A sparse filter reduces noise based on such a sparse representation of the signal. One example of how a filter might operate in this analogy would be to remove all buildings below a certain height.

51. A sparse de-noising filter can operate on any suitable signal, including signals that happen to be sparse (e.g. mostly a blank screen) or non-sparse (e.g. a typical video image with movement and detail) in their original representation; but a sparse de-noising filter is distinguished from other filters by its ability to take the input signal, consider a different, sparse representation that still represents the original data, and then reduce noise based on this sparse representation of the signal. For example, in the above analogy, a different cityscape with only a handful of skyscrapers (and no other buildings) could be considered a naturally sparse signal. A filter designed to reduce noise by changing perspectives to the skyline view to differentiate the skyscrapers from the other buildings would operate in the same way

whether the input signal was such a naturally sparse signal with just a few buildings, or a non-sparse signal comprised of all the buildings in Manhattan. In sum, one cannot determine that there are only skyscrapers (i.e. signal of interest) and no shorter buildings (i.e. quantization noise) without changing the perspective to a sparse representation.

#### **B. Dr. Reader’s Remaining “sparse de-noising filter” Constructions**

52. I understand that Dr. Reader alleges that the challenged claims of Grounds 1B and 3 are obvious under any of the four constructions Dr. Reader identified. Reader, ¶¶178 (discussing Ground 1B), 261 (discussing Ground 3). However, as I explain below when discussing each of these Grounds, I disagree with the conclusion that these Grounds render the claims obvious for reasons that do not depend on which “sparse de-noising filter” construction is applied.

### **IX. BACKGROUND**

53. Video compression coding, often abbreviated to video coding, is the process of compressing (encoding) video prior to transmission or storage and decompressing (decoding) compressed video so that it can be displayed. A video encoder converts digital video into a compressed form known as coded or compressed video, suitable for transmission or storage, and a video decoder converts coded or compressed video into uncompressed digital video. Together, the pair of a video encoder and decoder are known as a video codec.

54. A video compression specification describes a bitstream format and a mandatory decoding process and may also describe optional processes. Thus, a decoder that operates in accordance with a video compression specification must (at a minimum) follow the mandatory decoding process to decode video frames. VC1, 1 (VC1 reference “defines the bitstream syntax and semantics for compressed video data in VC-1 format” and “describe[s] the complete process required to decode the bitstream”).

55. An encoder must produce a bitstream that can be decoded by the mandatory decoding process. Examples of well-known video coding specifications at the time of the '556 Patent in 2006 included the ISO/IEC MPEG-2 (Video) and ISO/IEC MPEG-4 Part 2 (Video) standards, the ITU-T H.264 Advanced Video Coding (AVC) standard, also published as ISO/IEC MPEG-4 Part 10, and the SMPTE VC1 specification

56. An “in-loop” filter is a filter that can be applied within the decoding process, such that filtered video frames are stored as reference frames and are used to predict further decoded frames. An in-loop filter at the decoder must be identical to any in-loop filter applied at the encoder, since both encoder and decoder must create identical predictions from identical stored reference frames. This means that if in-loop filtering is in use at the encoder, the decoder also applies that same in-loop filtering.

57. Additionally, a POSITA would have understood at the time of the '556 Patent that in-loop filtering affects compression performance, as each filtered frame is stored and used as a reference frame for future prediction. There is also a fixed computational burden associated with an in-loop filter. This is not the case for an out-of-loop filter, which has the flexibility to be switched off (not applied) in order to reduce computation at the decoder. In my opinion, while in-loop filtering may have a positive effect on compression, such optimization is a complex and involved process, involving significant experimentation.

58. For these reasons, well-known video coding specifications at the time of the '556 Patent, such as VC1, contemplated the use of optional post-processing filters. As Dr Reader states, “[VC1] is an SMPTE (the Society of Motion Picture and Television Engineers) standard based on WMV9 (Windows Media Video 9) developed by Microsoft.” Reader, ¶124.

59. VC1 specifies a single in-loop deblocking filter as well as optional post-processing filters. Reader, ¶125. Every VC1-compliant decoder must implement and apply the in-loop deblocking filter during decoding. The encoder must apply the same filter when storing frames for prediction. The VC1 in-loop filter therefore affects compression efficiency and image quality and must be applied by the decoder.

60. As mentioned above, VC1 also specifies optional post-processing filters. Reader, ¶125. A decoder need not implement or apply these filters and therefore has the flexibility to disable the filters in view of, among other things, computational complexity required by the filter. *See* VC1, 452 (“the postprocessing filters described in this Annex may be applied by the decoder after decoding”); VC1, 9 (“A conformant implementation need not implement optional provisions (‘may’) and need not implement them as described”). Whether or not the post-processing filters are applied has no effect on stored reference frames or on compression performance.

#### **X. OPINIONS REGARDING GROUND 1A OF THE PETITION.**

61. In my opinion, Lee’s deringing filter is not an adaptive sparse de-noising filter.

62. As I explain above in the Claim Construction section (*see* §VIII.B), Dr. Reader analyzes Lee under only one construction of the “adaptive sparse de-noising filter” term and does not address the other constructions proposed by Petitioner. Reader, ¶¶147-148. Dr. Reader’s interpretation reads “sparse de-noising filter” as a “filter that reduces noise based on a sparse representation of the signal, which encompasses a sparse signal.” Reader, ¶137. In the Claim Construction section, I explained why Dr. Reader’s interpretation of InterDigital’s construction is incorrect.

63. I note that “Petitioner concedes that the Challenged Claims are not unpatentable as obvious over Lee alone” if the “ITC Staff’s” proposed construction is adopted. Petition, 71 n.7. The ITC Staff’s proposed construction is “a filter that reduces noise based on a sparse representation of the signal.” Petition, 14; EX1025; EX1032; EX1033. I agree that Lee does not disclose a filter that reduces noise based on a sparse representation of the signal.

64. Dr. Reader asserts that “Lee’s deringing filter is an ‘adaptive sparse de-noising filter’ under [InterDigital’s] interpretation because it 1) creates an ‘edge map’ of an image (‘a sparse representation of *a signal*’) and 2) performs filtering ‘based on’ said edge map.” Reader, ¶148 (emphasis added).

65. A POSITA would not have agreed with this conclusion. A POSITA would have understood that Lee’s edge map is not “a sparse representation of the signal” because the edge map does not represent the input signal being decoded, i.e., the image pixel data. Reader, ¶165. In Lee’s edge map, the image pixel data of the signal being decoded (i.e., the signal) has been irreversibly deleted and replaced with a set of binary “1” or “0” values. For context and comparison, a POSITA would have understood that each pixel in a video image that is being decoded is typically represented with at least 8 bits for greyscale, or luma component, plus 8 bits each for red and blue colour difference, or chroma components. Using 8 bits or more for luma, each pixel can represent a range of tonal values between black (0) and white

(255). These values, along with colour values, correspond to image pixel data. With a larger bit depth (so-called High Dynamic Range video), even more tonal values can be represented in the luma component. Lee's "one" or "zero" values cannot reflect any such tonal or colour range and therefore do not represent the image pixel data.

66. As I explained in the Claim Construction section, a sparse representation is a perspective of the input signal in which certain components of the signal can be more easily discriminated, but, importantly, this sparse representation must still represent the original input data. As mentioned above, this is not the case in Lee's edge map, which irreversibly deletes pixel data.

67. Again, the Manhattan building analogy illustrates this concept. Changing the perspective of one's view of Manhattan from a bird's eye view to the skyline view is consistent with a sparse representation because we have not changed or leveled any buildings in this change of view; instead, we have only moved our viewpoint of the buildings, *i.e.*, we have represented the information in a different domain. The information from the bird's eye view is still present in the skyline view, but it is in a different domain or a different representation. This is unlike Lee's edge map, where nearly all of the information from the original view (the image pixel data values, each representing a wide range of tonal values and typically colour values) is lost and instead replaced with "entirely ones and zeros." Reader, ¶148.

68. Dr. Reader also alleges that “[t]he resulting edge map is made up of entirely ones and zeros that represent the location of the edges in the original image.” Reader, ¶65. But Dr Reader cannot claim Lee’s edge map values represent “the original image.” The original image data is not represented by Lee’s edge map and is not recoverable using the information in Lee’s edge map.

## **XI. OPINIONS REGARDING GROUND 1B OF THE PETITION.**

69. I incorporate by reference the above opinions regarding Lee into this section.

### **A. Petitioner Characterizes the ’556 Patent Inventors’ Findings as “AAPA.”**

70. Dr. Reader identifies passages in the ’556 Patent that in my opinion are findings of the inventors rather than admitted prior art.

71. Dr. Reader asserts that the inventors of the ’556 Patent admitted that it was known that “[t]he signal after . . . deblocking filter is a better match to the independent and identically distributed (i.i.d.) noise presumption.” Reader, ¶120. I disagree. This passage is from the “detailed description” of the ’556 Patent at column 14 lines 22 to 30. A POSITA would have understood that these lines are not describing Applicant Admitted Prior Art (“AAPA”). Instead, the cited passages describe the disclosed invention’s unexpected results and advantages over the prior art. ’556 Patent, 14:24-30 (“The present principles *differ from the prior art* in the use of a series of refinement steps (succession of filters) after for example, the

MPEG-4 AVC Standard deblocking filter, each oriented to correct at least one part of the coding artifacts. The signal after deblocking filter is a better match to the independent and identically distributed (i.i.d.) noise presumption.”) (emphasis added).

72. Dr. Reader also states that the '556 Patent explains the sparse denoising filter described at column 2 lines 25-27 “was designed for additive, independent and identically distributed (i.i.d.) noise removal.” Reader, ¶118 (quoting '556 Patent, 2:25-27). Dr. Reader later offers his opinion that the need to accommodate a filter designed for i.i.d. noise would have led a POSITA to the claimed succession of filters. Reader, ¶188. But Dr. Reader does not consider that a POSITA would have understood the AAPA teaches away from reliance on i.i.d. noise models and adapts its filter method for non i.i.d. noise removal. Indeed, Guleryuz, which is the reference being described by the AAPA, explains that “One must. . . especially be cautious against using methods that are too dependent on the i.i.d. noise model” and, accordingly, “unlike the additive i.i.d. noise case . . . [Guleryuz] thus adopt[s] the robust estimate...  $\hat{c}$ ”. Guleryuz (EX1010), 2; EX1005, 137 ('556 Patent provisional application confirming the recently proposed filter described in the specification’s background section is by “Onur G. Guleryuz, in ‘A Nonlinear Loop Filter for Quantization Noise Removal in Hybrid Video Compression,’ Proc. IEEE Int’l Conf. on Image Proc. (ICIP2005), Genova, Italy,

Sep. 2005”). The passages of the ’556 Patent cited by Dr. Reader demonstrate the inventor’s finding that known approaches such as Guleryuz reduced reliance on i.i.d. noise models rather than the ’556 Patent inventors’ approach, which solved the problem in a new, novel way, through the use of successive in-loop filters to unexpectedly present “a better match to the independent and identically distributed (i.i.d.) noise presumption.” ’556 Patent, 14:24-30.

73. Dr. Reader, quoting the ’556 Patent, also states that a POSITA would have understood that the main drawback of using the AAPA (Guleryuz) filter is that it “‘may get confused by true edges or false blocky edges’ and attempting to solve the confusion with ‘spatiofrequency threshold adaptation ... is not trivial in its implementation,’ and ‘might result into over-smoothed reconstructed pictures or blocky artifact(s)’” Reader, ¶189 (quoting ’556 Patent, 2:25-37).

74. In my opinion, however, the lines from the ’556 Patent that Dr. Reader quotes refer to the inventive findings of the inventors. For instance, Dr. Reader cuts off the beginning of the passage which begins “*[t]his implies* that these techniques may get confused by true edges or false blocky edges.” ’556 Patent, 2:30-31. A POSITA reading this passage would understand the inventors to be describing their findings regarding the prior art and the problem to be solved by the ’556 Patent’s invention, rather than admissions as to the prior art itself. The Guleryuz paper (EX1010) in fact states the opposite, suggesting that by using the Guleryuz filter,

“texture and edge information is preserved while artifacts are suppressed” (at page 3) which means that Guleryuz teaches its filter could indeed handle true edges and false blocky edges effectively when used in the test configuration reported in the Guleryuz paper. Guleryuz (EX1010), 3. In my opinion this is most likely because the Guleryuz paper does not attempt to implement the Guleryuz filter as an in-loop filter, but rather as a postprocessing filter (Guleryuz (EX1010), 4). Thus, nothing in the Guleryuz paper itself suggests that the “main drawback” of using an adaptive sparse denoising filter on its own as an in-loop filter was known in the prior art, as suggested by Dr. Reader. Reader, ¶189.

75. Dr. Reader does not identify any other support for the assertion that it was known that the signal after the deblocking filter is a better match to the i.i.d. noise presumption or that the Guleryuz filter may get confused by true edges or false blocky edges, other than the passages from the '556 Patent which, in my opinion, reflect the inventor's own findings and not what was known in the art. In my view, a POSITA would not have known or understood these assertions to be true from the AAPA in the '556 Patent.

76. For the reasons stated above, I disagree that the above passages should be considered admitted prior art. A POSITA would have understood that these passages describe the '556 Patent inventor's own findings as to the Guleryuz filter and MPEG-4 deblocking filter as well as the inventors' analysis of the

problems posed by their use as in-loop filters in the process of decoding compressed video frames.

77. Based on the information I have reviewed, the '556 Patent inventors were the first to recognize the problems identified in the above passages of the '556 Patent and to identify the solution that is disclosed and claimed in the '556 Patent. Specifically, the '556 Patent inventors identified a need, a motivation to solve it, and the drawbacks of using other sparse de-noising filters, e.g. Guleryuz, as in-loop filters in video compression. '556 Patent, 2:31-47, 14:22-30.

**B. A POSITA Would Not Have Modified Lee to Utilize the Guleryuz Filter Addressed By the AAPA.**

78. The Guleryuz paper refers to in-loop deblocking filters (such as the MPEG-4 deblocking filter and the VC1 deblocking filter) as “traditional systems,” in which the “primary utilized model is an image having smoothly varying pixel values, and the designed filters typically consist of a bank of low-pass filters.” Guleryuz, 1.

79. The Guleryuz paper states that traditional deblocking filters utilize a smooth image model that is not always applicable and thus such filters may not handle images correctly, may provide limited improvements in rate, and may exhibit poor “visual quality, especially around edges and other singularities.” Guleryuz, 1. Thus, Guleryuz informs a POSITA that deblocking filters “inclusion in modern

codecs is not always a clear-cut decision from a performance vs. complexity standpoint.” *Id.*

80. A POSITA would understand that Guleryuz specifically teaches away from using multiple, separate, filters because it instructs that its single filter is designed to “replace traditional systems,” *i.e.*, known deblocking filters. Guleryuz, 1- 2. The Guleryuz paper explains “it is very beneficial to have a single filtering solution that is applicable in the general case.” *Id.* In my opinion, the Guleryuz filter was designed and intended to be used alone to filter all types of quantization noise. Guleryuz, 2-3; *see also* ’556 Patent, 2:13-14 (describing Guleryuz); Reader, ¶268 (“Guleryuz’s filter reduces quantization noise . . . [s]uch noise includes both blocking artifacts and artifacts around sharp edges.”)

81. Guleryuz also explains that using sparse denoising techniques to attempt to denoise decompressed video frames was known to be complex and difficult. Guleryuz, 1-2. The focus of the Guleryuz paper is that “trying to carry over this simple recipe” of sparse denoising techniques “to quantization noise reduction from decompressed video frames presents many significant issues.” Guleryuz, 2. Guleryuz notes three significant problems: (1) reliance on i.i.d. noise models, which Guleryuz states do not apply well when denoising decompressed video frames; (2) “differentially compressed frames pose challenges since they can be coarsely quantized, and unless one is careful, one may repeatedly filter the information from

the anchor” because “[h]igh performance video codecs utilize a multitude of frame types that are not amenable to established literature on still image denoising and artifact removal”; and (3) “[w]hile accomplishing the denoising rule solely in the coefficient domain where the data is expected to be sparse has proven to be a good idea in still images, in video there is potentially lucrative side information available by consulting previously decompressed frames.” *Id.*, 2.

82. Guleryuz’s single filter was so computationally intensive that the authors of Guleryuz ran simulations with many parameters turned off or simplified “to curb processing complexity.” Guleryuz, 4. The Guleryuz paper also applied the proposed filter out of loop, rather than in-loop, in the simulations, *i.e.*, applying the proposed filter as a post-processing filter and not as an in-loop filter. *Id.* Even when applied as a post-processing filter (rather than as an in-loop filter) and with the above-described efforts to curb complexity, Guleryuz’s filter accounted for twenty percent of the computational complexity of the entire decoder. *Id.* A POSITA would understand that an increase of twenty percent of a decoder’s computational complexity is a significant amount that in many applications would be unsustainable.

83. Dr. Reader asserts that the AAPA (Guleryuz) filter and Lee’s deblocking filter would have worked “synergistically with each other.” Reader, ¶189. I disagree. Guleryuz does not contemplate and/or describe its filter in succession with a deblocking filter or with any other filter. To the contrary, Guleryuz

discloses a single filter solution (*i.e.*, only using the Guleryuz filter) and is designed to reduce all types of quantization noise, including to reduce blocking artifacts. EX1010, 3 (“[T]exture and edge information is preserved [by the proposed filter] while artifacts are suppressed”). Thus the Guleryuz paper provides no guidance or suggestion for implementing the filter in conjunction with a deblocking filter or within a coding loop, nor any suggestion that such a combination would improve compression performance or image quality. A POSITA would not have simply assumed that such a combination improved compression performance or image quality. This is due in part to the fact that any change to in-loop filtering has a cascading effect on other frames that are coded using prediction from the filtered frame. For example, assume a modified in-loop filter is applied to frame 1, then frame 2 is predicted from frame 1, and then frame 3 is predicted from frame 2. The modified processing of frame 1 affects the prediction of frame 2, which in turn affects the prediction of frame 3. In my opinion, to determine whether this modified approach resulted in any appreciable compression gain (or indeed compression loss) would require undue experimentation. Specifically, a POSITA would be required to evaluate the change in motion compensated prediction (whether beneficial or detrimental) against the cost of additional computational complexity due to multiple in-loop filtering processes. Thus, in my opinion, a POSITA would not have understood how a potential combination of Lee and the AAPA (Guleryuz) filter

would work together or how to put the teachings of the two references together or whether such a combination would have any beneficial effects without undue experimentation.

84. Further, Guleryuz describes its filter as “robust” and computationally demanding. Guleryuz’s experimental results were obtained with many parameters modified to reduce complexity and without even implementing the proposed filter inside the decoding loop. Despite all of this simplification, the Guleryuz filtering operations still demanded 20% of the entire decoder computational complexity. Guleryuz, 3-4.

85. I note that Guleryuz himself was unable to successfully implement his own proposed filter within the decoding loop, which further supports my opinion that it would not have been obvious or straightforward for a POSITA to do so. Guleryuz, 4 (stating that the proposed filter was “applied” “as a postprocessing filter”).

86. Lee, on the other hand, states that its goal is low complexity and can be carried out by performing simple shift and addition operations such that “[t]he method according to the present invention can be performed by a parallel processing without multiplication and division, thereby reducing the complexity of hardware.” Lee, ¶[0119]. Lee contrasts its “simple” method with the “methods [of the prior art that] require complicated computations.” Lee, ¶[0008]; *see also id.*, ¶¶[0004]-

[0007]. In my opinion, a POSITA would have understood that the AAPA addresses Guleryuz's complex filter and adding Guleryuz's computationally complex filter into Lee's process would contradict Lee's stated purpose of coding video "without need for complicated computations." Lee, ¶[0009].

87. In my opinion, Dr. Reader fails to provide any support, beyond hindsight, for his assumption that a POSITA would have simply been able to insert Guleryuz's complicated filtering solution after Lee's deringing filter *or* in place of Lee's deringing filter and create a working filtering solution that added any compression, image quality or other benefits to Lee's system. Indeed, a POSITA would not have had reason to add Guleryuz's robust and computationally complex filter into Lee's simple and reduced-complexity process. As I explain above, Guleryuz himself was unable to test his own filter within the coding loop (Guleryuz, 4) and so a POSITA would have no evidence available as to the effect (beneficial or otherwise) of implementing Guleryuz' filter within Lee's coding loop, alone or in conjunction with Lee's existing filters.

88. Further, Dr. Reader fails to analyze or explain why a POSITA would be motivated to modify Lee such that it performed deblocking, corner outlier compensation, and deringing, followed by Guleryuz's filter (which itself already reduces blocking and ringing artifacts, *see* EX1010, 3), all within the coding loop. Reader, ¶190. In my view, a POSITA would not only not be motivated to do so, but

also would find this combination to be redundant because Guleryuz's filter reduces blocking artifacts but, in Dr. Reader's proposed modification, would be applied after Lee's existing deblocking filter.

89. A POSITA would have understood the significant challenges and potential drawbacks of adding a filter into the coding loop, compared with (for example) applying a post-processing filter outside the coding loop. These challenges include the following. First, an in-loop filter can have a significant impact on the computational complexity of a decoder. Both encoder and decoder must use identical in-loop filters, as I explain earlier. *See* §IX (Background) above. This means that if in-loop filtering is in use at the encoder, the decoder also applies that same in-loop filtering. There is therefore a fixed computational burden associated with an in-loop filter, which is not the case for an out-of-loop filter, which the decoder can choose to switch off (not apply), in order to reduce computation at the decoder. *See* VC1, 459 (decoder evaluating computational complexity to determine whether to disable one or more out-of-loop filters). An out-of-loop filter, unlike an in-loop filter, can be switched on or off dynamically by a decoder, for example to avoid running out of computational resources when decoding video in real time. Second, an in-loop filter has an effect on compression performance. Each filtered frame is used as a reference for predicting further video frames, which in turn themselves are used as prediction references. There is therefore a 'cascade' effect of any change in in-loop

filtering. With careful design, in-loop filtering may have a positive effect on compression, but in my experience such optimization is a complex and involved process, involving significant experimentation. In my view, a post-filter or out-of-loop filter will not necessarily have a positive effect on compression if redesigned as an in-loop filter. The goal of a post-filter is (typically) to improve visual appearance of decoded frames, whereas the goal of an in-loop filter is to improve motion compensated prediction of future decoded frames, *i.e.*, to minimize motion compensated residual data. These goals cannot necessarily be met by the same filter process. In other words, a filter designed for in-loop filtering may not be optimal for post-processing and vice versa.

90. Further, even the references that Dr. Reader relies upon in his Declaration highlight the differences between applying filters in-loop versus out-of-loop. For example, the Lin reference relied on by Dr. Reader in Ground 2 highlights this difference and contradicts Dr. Reader's general view that out-of-loop filter teachings equally apply to use in the coding loop when it states that "filters used for deblocking in post-processing can introduce too much smoothing in reference frames used for motion estimation/compensation." Lin, ¶117. Here, Lin is explaining that a filter designed for post-processing (*i.e.* applied to frames that are not used for further motion compensation) may not be optimal or suitable for in-loop filtering (*i.e.* applied to frames that are used for further motion compensation).

91. In view of the above, I disagree with Dr Reader’s assertion that it would have been obvious to combine Lee’s in-loop filtering design with the Guleryuz filter. As I explain below, Lee’s system already deals with multiple types of quantization artifacts including blocking, corner effects and ringing; Guleryuz’ filter was untested as an in-loop filter but claims to duplicate the artifact removal of Lee; and there is no experimental evidence or analysis to show that such a combination would improve (rather than reduce) the compression efficiency of Lee.

92. Dr. Reader provides his opinion that it would have been obvious to try the proposed combination of Lee and the Guleryuz filter addressed by the AAPA. Reader, ¶189 (stating the combination would have been “no more than combining prior art elements . . . according to known methods . . . to yield predictable results”); *see also id.*, ¶189 (stating the combination “would have been no more than applying a known technique . . . to a known device ready for improvement . . . to yield predictable results”), ¶190 (stating the combination “would have been no more than a simple substitution of one known element for another to obtain predictable results”), ¶191 (stating that adding Guleryuz’s filter along with Lee’s deringing filter “would have been no more than use of a known technique . . . to improve similar devices . . . in the same way”). I disagree with each of these statements and the conclusion that it would have been obvious to try modifying Lee with Guleryuz in the manner proposed by Dr. Reader.

93. The '556 Patent is directed to solving the problem of how to address the many aspects of quantization noise or compression artifacts, beyond just blocking artifacts, in the context of encoding and decoding compressed video frames. *See* '556 Patent, 1:5-2:3, 4:58-61. A POSITA would have understood that there were many potential solutions to this problem, not a finite number of identified, predictable solutions. For example, Guleryuz's single filter, by itself and applied outside the coding loop, is one such solution. Guleryuz's single filter, by itself and applied inside the coding loop, is another solution. Likewise, a POSITA could have added any number of other filters outside of the coding loop, added filters before the deblocking filter, added more intervening processes after the deblocking filter along with Lee's corner outlier compensator, or utilized a filter or multiple filters in parallel with the deblocking filter (as is done in the Samadani reference cited by Dr. Reader). Reader, ¶¶75-76; EX1026, Fig. 4. A POSITA would have therefore understood that there are a very large number of potential solutions to the problem to be solved by the '556 Patent. Dr. Reader supports his opinions with the idea that, in the proposed Lee and Guleryuz combination, "a POSITA would have been able to individually tune and optimize filters to reduce artifacts" (¶191), but this does not in my view support a motivation to modify Lee with Guleryuz because, for instance, Lee's existing process already allows for this without requiring Guleryuz, since

Lee's loop-filtering process (Lee Fig. 1) has at least three processing stages, the deblocking filter, corner outlier compensator and deringing filter.

94. Far from an "obvious to try" simple substitution, as Dr. Reader states (Reader at 189), in my opinion a POSITA would be faced with a very large number of options to consider in order to address the many aspects of quantization noise in compressed video images. Even if a POSITA were to consider Lee and Guleryuz in combination, which I disagree with as I explain above, such a combination would in my view have required undue experimentation to apply the AAPA Guleryuz filter, described in Guleryuz as computationally complex, in the proposed way within Lee's simple filtering process. Even assuming a POSITA were to combine Lee and Guleryuz, the teachings of Guleryuz would in my view have led a POSITA to replace both of Lee's separate filters (deblocking and deringing) with Guleryuz's single filter that itself reduces blocking artifacts, because this is what Guleryuz specifically instructs. Guleryuz 1-2 (The proposed filter "can replace traditional systems," *i.e.*, "loop filters [that] are designed to alleviate blocking artifacts"). Thus, I disagree with Dr. Reader's suggestion that a POSITA reading the Guleryuz and Lee references would have been motivated to reach the same solution that the inventors of the '556 Patent arrived at.

## **XII. OPINIONS REGARDING GROUND 2 OF THE PETITION.**

### **A. Chiang Does Not Disclose or Teach Two Filters Used In the Coding Loop With a Deblocking Filter for Performing a First Pass.**

95. Dr. Reader alleges that Chiang teaches using its two disclosed filters in-loop and with the deblocking filter performing a first pass as required by the claim limitations. Reader, ¶¶225-6. I disagree that a POSITA would have understood Chiang to disclose either of these limitations. First, Chiang does not disclose using two filters within the coding loop (the claimed “in-loop filtering”). Instead, Chiang contemplates that one, or the other, of the deblocking unit or edge filter may be applied in the coding loop but never discloses both filters used in-loop, let alone that the two filters are used in succession in the coding loop. Chiang, ¶¶34, 40-41.

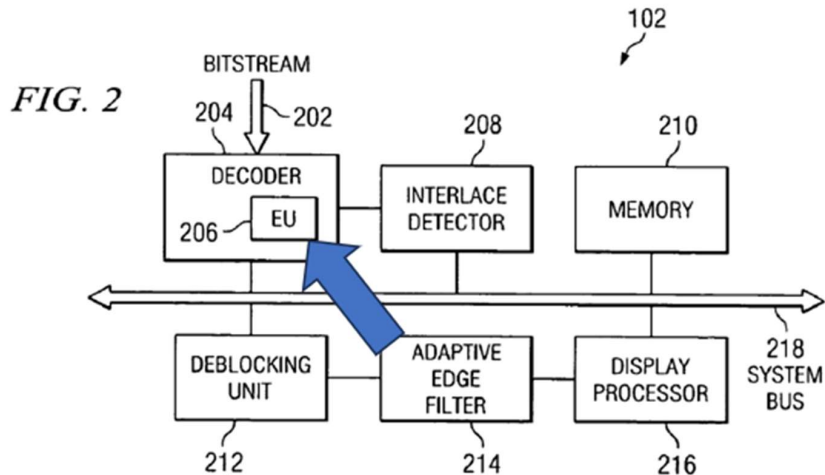
96. Dr. Reader does not cite an embodiment in Chiang that performs filtering using an in-loop deblocking filter in a first pass with an in-loop adaptive sparse de-noising filter for performing a second pass. *See* Reader, ¶225. Instead, Dr. Reader admits that the passages he relies upon for the disclosure of filters where both filters are used with the deblocking filter for performing a first pass concern Chiang’s out-of-loop embodiment. *Id.*

97. Dr. Reader instead asserts “a POSITA would have understood that [Chiang’s out-of-loop embodiment] teachings *equally apply* to an in-loop implementation” and that “a POSITA would have understood that Chiang teaches applying the same order of filters in-loop.” Petition, 46 (emphasis added). Dr. Reader

cites to Chiang Paragraphs 34 and 40 for support. However, neither cited paragraph discloses implementing both filters in-loop, let alone in succession with the deblocking filter applied in a first pass, and in my view a POSITA would not have simply assumed that (a) both filters could readily be applied in loop in the manner suggested and (b) would still operate as intended. I incorporate by reference my discussion above regarding why a POSITA would not have simply added filters into the coding loop without further considerations not addressed by Dr. Reader. *See* §XI.B above (regarding challenges of adding filters into the coding loop).

98. Dr. Reader cites Paragraph 34 of Chiang, stating that edge filtering “could operate after motion compensation during image decoding” or “after in-loop filtering” as supporting the contention that Chiang’s out of loop teachings “equally apply” to in-loop implementations. Reader, ¶225 (citing Chiang, ¶34). I disagree. Chiang Paragraph 34 describes an alternative to Figure 2’s embodiment, which shows out-of-loop filtering, modified such that edge filtering is used “after motion compensation during image decoding.” Chiang, ¶34. A POSITA would have understood this to teach applying the edge filter in a first pass after motion compensation, which is unlike the configuration in Chiang’s out-of-loop embodiment and also unlike the Challenged Claims. I have shown this below with a blue arrow. Thus Paragraph 34 describes an implementation [embodiment] in which

edge filter 214 is applied first within Decoder 204, rather than after deblocking filter 212 as shown in Figure 2.



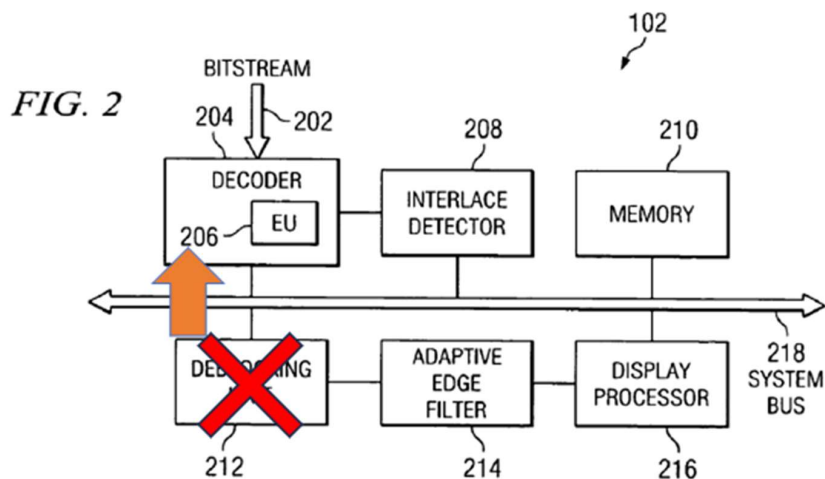
Chiang, Fig. 2 (annotated). However, as can be seen, this alternative embodiment does not support Dr. Reader’s assertion to apply both filters in loop in the same order shown in Figure 2, with a deblocking filter for performing a first pass and the edge filter for performing a second pass.

99. Likewise, in the embodiment in which the edge filter is used “after in-loop filtering of decoded images” (Chiang, ¶34), the edge filter remains out-of-loop while in-loop deblocking is carried out. Here, too, a POSITA would have understood Chiang to only ever describe a single filter in the coding loop.

100. A POSITA would have also understood that Chiang’s statement in Paragraph 34 that the edge filter “may be used at any suitable point during processing of images by the image decoder 102” is in the context of an embodiment where one filter remains out of the decoding loop (Chiang Fig. 2). This supports my opinion

that a POSITA would have understood Chiang to only ever describe a single filter in the coding loop.

101. Dr. Reader also cites Paragraph 40 of Chiang to support his conclusion that Chiang teaches using both filters in loop in the order shown in Figure 2. Reader, ¶225. I disagree because Paragraph 40 instructs that “the deblocking unit 212 may be omitted from the image decoder” if “in-loop filtering to reduce or eliminate blocking artifacts” is being used. Chiang, ¶40. Here, Chiang does not teach use of an in-loop deblocking filter for performing a first pass in succession with a second filter in the coding loop. Rather, it teaches the opposite, “omit[ting]” the deblocking unit when applying in-loop filtering, while leaving the edge filter 214 out of the coding loop. I have annotated this embodiment below.



102. In summary, a POSITA would have understood that Chiang teaches applying at most one of its filters in-loop and does not teach applying two filters in-

loop with the deblocking filter applied in a first pass and the edge filter for performing a second pass.

103. In my view, a POSITA would not have been motivated to add multiple filters into the coding loop as Chiang itself does not contemplate using more than a single filter in-loop. A POSITA would have understood Chiang's teaching, which is to apply at most one filter in loop while the other filter remains out of the coding loop to mitigate the complexity of applying filters in-loop while maintaining flexibility due to the use of out-of-loop filters. Dr. Reader never addresses the added complexity and loss of flexibility that would result from applying multiple filters within the coding loop. Petitioner and Dr. Reader fail to explain the connection between the alleged motivation ("to increase the predictability of buffering images") and the alleged modification to modify Chiang to "an in-loop implementation." Reader, ¶225. I incorporate by reference my discussion above regarding why a POSITA would not have simply added filters into the coding loop without further considerations not addressed by Dr. Reader. *See* §XI.B above (regarding challenges of adding filters into the coding loop).

104. It is also unclear as to what Dr. Reader means when he says "increas[ing] the predictability of buffering images." *Id.* To the extent this is meant to imply that further motion compensated prediction from decoded frames would be improved, resulting in a compression gain, neither Petitioner nor Dr. Reader provide

evidence that this would be the case, and a POSITA would not assume this. As explained above when discussing Dr. Reader's proposed Lee and Guleryuz combination, understanding whether or not such an improvement occurred would also require undue experimentation because filtering has a cascading effect on other frames that are coded using prediction from the filtered frame. Indeed, Dr. Reader acknowledges that even "having to code an additional filter flag" within the coding loop process comes "at the expense of slightly reduced compression" (Reader, ¶280), yet Dr. Reader does not evaluate the consequences of adding significant complexity into the coding loop in the context of his opinions regarding Chiang. Accordingly, a POSITA would not have understood Dr. Reader's suggestion to depart from Chiang's teaching and apply multiple filters within the coding loop to result in the benefit of "increase[ing] the predictability of buffering images."

105. Thus, given Chiang's lack of disclosure of an in-loop embodiment with both filters, Dr. Reader never articulates why a POSITA would allegedly be motivated to depart from Chiang's teachings to apply its filters in-loop with the deblocking filter applied in a first pass. Reader, ¶¶225-226.

**B. Chiang Does Not Disclose or Teach an Adaptive Sparse De-noising Filter.**

106. Dr. Reader asserts that "Chiang's adaptive edge filter is an adaptive 'sparse de-noising filter' that reduces noise under PO's current ITC construction." Reader, ¶229. I disagree. Dr. Reader never analyzes whether Chiang's edge filter is

a “sparse de-noising filter” under any of the proposed constructions, including the construction requiring that the filter “reduces noise based on a sparse representation of the signal.” In fact, Dr. Reader does not address whether Chiang discloses a “sparse representation” at all. *See* Reader, ¶¶227-229.

107. Instead, Dr. Reader only identifies the effect of the accused filter in the ITC action (that the filter prevents excessive blurring when applied across an edge) and appears to conclude that any filter which “prevents excessive blurring when applied across an edge” is the claimed sparse filter. Reader, ¶229. In my view, Dr. Reader’s conclusion is unfounded. Based only on his own conclusion, Dr. Reader alleges that Chiang discloses a “sparse de-noising filter” because it “may perform edge adaptive filtering to reduce or remove ringing artifacts near edges.” Reader, ¶229 (citing Chiang, ¶41). In my opinion, a POSITA would not have understood that Chiang’s filter is “a filter that reduces noise based on a sparse representation of the signal,” or even Dr. Reader’s misinterpretation requiring only a “sparse signal,” simply by comparing the effect of Chiang’s filter to the effect of another filter. Indeed, a POSITA would be aware of filters that adaptively filter edges, but which are not sparse de-noising filters, because the filters do not reduce noise based on a sparse representation of the signal. *See supra*, §VIII; *see also* §X (where I explain why Lee does not disclose a sparse denoising filter). Dr. Reader

acknowledges examples of such filters, including the Sobel edge-detection filter which Dr. Reader states is “not sparse.” Reader, ¶64.

108. Additionally, Dr. Reader alleges that Chiang’s system “uses the distance between a pixel of interest and an edge to identify a filter weight” to “reduce or remove ringing artifacts near edges and in flat regions of decoded images.” Reader, ¶229 (citing Chiang, ¶31). Neither Petitioner nor Dr. Reader explain how this disclosure means that Chiang’s filter is an adaptive sparse de-noising filter under any proposed construction, and a POSITA would not have assumed this to be the case. On the contrary, a POSITA would have understood that an adaptive sparse denoising filter needs to reduce noise based on a sparse representation of the signal and Dr. Reader never opines that Chiang’s filter is such a filter. *See supra*, §VIII..

### **XIII. OPINIONS REGARDING GROUND 3 OF THE PETITION.**

109. Dr. Reader alleges that a POSITA would have been motivated to combine the teachings of the VC1 Standard and Guleryuz by applying Guleryuz’s in-loop denoising filter after the VC1 Standard in-loop deblock filter. Reader, ¶269. I disagree.

110. Dr. Reader admits the purpose of VC1’s in-loop filter is to address blocking artifacts but “is silent regarding other coding artifacts.” Reader, ¶269; *see also* Petition, 58. I agree that VC1 is silent regarding other coding artifacts with respect to in-loop filtering. However, VC1 teaches reducing other coding artifacts

with its out-of-loop filters. Despite this, Dr. Reader alleges that a POSITA “looking to apply the teachings of [VC1]” would seek to add a second in-loop filter. Reader, ¶269. Dr. Reader’s only support for his assertion is “deblocking filters such as the one taught by the VC1 Standard have shortcomings in that they do not address other types of coding artifacts very well.” *Id.* Yet the fact that deblocking filters do not address every type of artifact does not mean that a POSITA would have been motivated to alter VC1’s solution, adding additional complexity without any expectation of improved image quality or improved compression, and certainly does not mean that a POSITA would have assumed that VC1 required Guleryuz’s filter as a second in-loop filter. Indeed, a POSITA would have appreciated that VC1 itself addressed the problem of coding artifacts not addressed by the in-loop deblocking filter, through its use of out-of-loop filters for coding noise reduction. VC1, 452.

111. Even if a POSITA were to combine Guleryuz and VC1, they would not have been motivated to do so in a manner that created two filters operating in-loop and in succession as required by the claims. Instead, a POSITA would at most be motivated to substitute Guleryuz for VC1’s deblocking filter. This is because Guleryuz discloses that its solution is intended to replace a filter such as VC1’s deblocking filter, which is a bank of low-pass filters just as the “traditional” deblocking filter systems that Guleryuz critiques. *See* VC1, 178-189. In fact, the paper that Guleryuz cites when disparaging “traditional” deblocking filter systems

(reference [7]) is S. Srinivasan, P. Hsu, T. Holcomb, K. Mukerjee, S. L. Regunathan, B. Lin, J. Liang, M.-C. Lee, and J. Ribas-Corbera, Windows Media Video 9: Overview and Applications, Signal Processing: Image Communication, Elsevier, 2004. Dr. Reader acknowledges that the VC1 reference he relies on is “based on WMV9 (Windows Media Video 9) developed by Microsoft”. Reader, ¶124. Thus, Guleryuz’s statement about the disadvantages of “traditional” deblocking filter systems is directed to the specific deblocking system in WMV9 that was later described in the VC1 reference applied in Ground 3. A POSITA would have understood Guleryuz’s teaching to “replace” such systems to likewise apply to VC1’s deblocking filter. Accordingly, neither VC1 nor the Guleryuz reference supports using two in-loop filters in succession. I incorporate my above discussion of Guleryuz and its teachings (and teaching away) here by reference. *See supra*, §XI.

112. Despite this, Dr. Reader alleges that a POSITA would have used “a second in-loop filter,” because this was “a common technique to improve the quality of decoded images,” and in-loop deblocking filters have “shortcomings in that they do not address other types of coding artifacts very well.” Reader, ¶269; *see also* Petition, 58. However, VC1 addresses other types of coding artifacts using out-of-loop filters in post-processing to achieve “coding noise reduction.” VC1, 452. Therefore, VC1 already contains a solution that resolves the “shortcomings” that form the basis for Dr. Reader’s alleged motivation to combine, while achieving the

stated “benefit,” with its out-of-loop “deblocking and de-ringing . . . operations” which “[d]ecoder[s] can use . . . to mitigate the effect of compression artifacts, and improve perceptual quality of video.” VC1, 18. Further, VC1 indicates that it is not a clear-cut decision to perform deblocking filtering and deringing filtering due to potential “perceptual degradation” in certain instances. VC1, 452.

113. Still further, a POSITA would have understood that VC1’s out-of-loop filters promote decoder flexibility, for example making it easy for a decoding device to switch filtering options on or off depending on available decoder computation, in contrast to in-loop filters that are typically defined by a specification and which must typically match any filtering applied by the encoder. VC1, 459; *supra*, §XI.B. In my opinion, VC1’s teaching to apply its filters for coding noise reduction out of the decoding loop, so that the decoder can choose to disable such filtering if it determines the computational complexity to be too high, teaches away from the multiple in-loop filters of the claimed invention. As discussed throughout this Declaration, a filter applied in the coding loop must be applied by the decoder for a given block if the encoder applied that filter, meaning that the decoder has less flexibility to control the computational complexity of the filtering process. A POSITA would have understood that VC1 has no need for a second in-loop filter and teaches away from the claimed use of at least two in-loop filters in succession.

114. Dr. Reader also relies on VC1’s “overlap smoothing” as a reason to use two in-loop filters. Reader, ¶269. However, this processing step is not designed to address other types of coding artifacts. VC1’s overlap smoothing reduces blocking artifacts and a POSITA would have understood this to be a form of deblocking filtering. Dr. Reader fails to acknowledge that VC1 teaches that “blocking artifacts can be minimized” across the edges of two neighboring Intra blocks by overlap smoothing. VC1, 175. This step is carried out “prior to in-loop deblocking,” the intent of which “is to smooth out the discontinuities at block boundaries.” VC1, 176. Thus, a POSITA would not have understood that VC1’s overlap smoothing supports the concept of applying different in-loop filters to address different types of coding artifacts and not just to address blocking artifacts.

115. Dr. Reader states that additional in-loop filters would be used because the “benefit of providing a higher quality reference frame that in-loop filtering provides” was well understood in the art. Reader, ¶269. However, a POSITA would have understood that the designers of VC1 were aware of Dr. Reader’s stated “benefit” and nevertheless limited VC1’s in-loop filtering to only blocking artifacts. Further, the proposed additional in-loop filter would require additional computational complexity (on top of the “robust” Guleryuz filter that itself demands at least 20% of the entire decoder’s computational complexity, as previously discussed). Dr. Reader admits that “‘processing speed and memory’ are taken into

consideration” by VC1, but fails to consider why a POSITA would implement additional in-loop filters in view of this teaching. In my view, a POSITA reading VC1 would not have added such additional complexity without a clear reason for doing so, such as an expectation of better compression performance and image quality. Such a motivation is not provided by Dr. Reader’s alleged combination and would have required undue experimentation.

116. I disagree with Dr. Reader that a POSITA would have been motivated to apply Guleryuz’s filter after the VC1 in-loop deblocking filter. To support his assertion, Dr. Reader alleges that the ’556 patent admits that it was known that “after removal or reduction of block artifacts, the remaining quantization noise is a much closer match to i.i.d. noise.” Reader, ¶270. However, the ’556 Patent states that Guleryuz’s “de-noising tool was designed for additive, independent and identically distributed (i.i.d.) noise removal, while quantization noise has significantly different properties, which can present significant issues in terms of proper distortion reduction and visual de-artifacting.” ’556 Patent, 2:25-30. As discussed above (*see supra*, §XI.A-B), which I incorporate by reference, the patent does not admit it was known that deblocking filters present quantization noise that more closely matches i.i.d. noise models; rather, the patent’s detailed description explains:

The present principles *differ from the prior art* in the use of a series of refinement step (succession of filters) . . . [t]he signal after deblocking filter is a better match to the independent and identically distributed (i.i.d.) noise presumption. . . . The succession of filters has shown its

superior performance in removing video compression artifacts, both in practice and theory.

'556 Patent, 14:18-36 (emphasis added). In my view, a POSITA would have understood from this that the fact that the remaining quantization noise is a much closer match to i.i.d. noise after removal or reduction of block artifacts was an unexpected, novel benefit that the inventors of the '556 Patent discovered.

117. I disagree with Dr. Reader that it would have been obvious to try to combine VC1 and Guleryuz in the manner suggested. Reader, ¶¶269-70. For example, a POSITA would have understood that Guleryuz's filter could be solely applied in the VC1 system, it could be applied out-of-loop before, after, or instead of either or both of the post processing filters in VC1. It could alternatively be applied before or simultaneous to the in-loop deblocking filter, and so on. Determining whether any of these combinations would be beneficial would in my view require significant and undue experimentation and would not be a matter of routine optimization. Indeed, VC1 already "contemplates a post-processing deringing filter to remove ringing artifacts." *Id.* Dr. Reader never evaluates why a POSITA would ignore the teaching of VC1 and would employ additional filters—especially the complex Guleryuz filter—in the coding loop. *See* §XI.B above (regarding challenges of adding filters into the coding loop). It is my opinion that, if a POSITA were to combine VC1 with another filter, they would not simply ignore this teaching.

#### **XIV. CONCLUSION**

118. In sum, it is my opinion that Grounds 1A, 1B, 2, and 3 of the Petition do not render Claims 1-8 of the '556 Patent unpatentable as obvious for the reasons I discuss above.