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IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF CALIFORNIA

CARNEGIE MELLON UNIVERSITY, Plaintiff, v. LSI CORPORATION and AVAGO TECHNOLOGIES U.S. INC., Defendants.	Civil Action No.___________ **JURY TRIAL DEMANDED**

COMPLAINT

Plaintiff Carnegie Mellon University ("CMU"), by and through its undersigned counsel, hereby files this Complaint against LSI Corporation and Avago Technologies U.S. Inc. (collectively, "Defendants"), alleging as follows:

NATURE OF THE ACTION

1. This action arises under the patent laws of the United States, 35 U.S.C. §§ 1, *et seq.*, from Defendants' willful direct and indirect infringement of method claims of United States Patent No. 6,201,839 ("the '839 Patent") and No. 6,438,180 ("the '180 Patent") (collectively, the "Patents").

2. CMU has long supported research and development of innovative data storage technologies. With this support, José Moura, a CMU professor, and Aleksandar Kavcic, Prof. Moura's then-Ph.D. student, developed the invention described in the Patents during their tenure at

CMU and assigned the Patents to CMU. The Patents generally claim a method used in a "read channel" for improving the accuracy of detecting data written to a storage medium, such as a magnetic disk in a hard disk drive ("HDD") thereby substantially improving the performance of the read channel and allowing for increased data density.

3. Defendants knowingly performed the patented methods in the United States and incorporated them into read channel products they sell that are specifically designed to perform the patented methods. Defendants performed the patented methods in the United States during the design, development, and testing of their read channel products, and gained a competitive advantage through the resulting improvement in data detection performance. Rather than compensate CMU for this domestic use of its technology, Defendants instead willfully have infringed the Patents.

PARTIES

4. CMU is a Pennsylvania not-for-profit corporation with its principal place of business at 5000 Forbes Avenue, Pittsburgh, PA 15213.

5. CMU is a global research university of more than 13,000 students, 100,000 alumni, and 1,350 faculty.

6. CMU is consistently one of the top-ranked universities in the United States according to the U.S. News & World Report's Best Colleges rankings.

7. CMU has been recognized for its world-class arts and technology programs, collaboration across disciplines, and innovation leadership in education.

8. CMU is deeply committed to fostering and supporting useful research. To maximize the public benefit that its research generates, CMU in some instances patents and/or commercializes inventions generated by its researchers. It then reinvests a portion of the revenue generated from its inventions back into its education and research programs.

9. Over the past 13 years, the United States Patent and Trademark Office ("USPTO") has awarded over 400 patents to CMU, thereby recognizing the innovative technologies generated by CMU researchers.

10. CMU has a branch campus in this judicial district, located in Silicon Valley at NASA Ames Research Park, Bldg. 23 (MS 23-11), Moffett Field, CA 94035. This campus offers a number

of graduate degrees in engineering and IT fields.

11. Defendant LSI Corporation ("LSI") is a Delaware corporation headquartered at 1320 Ridder Park Drive, San Jose, California 95131.

12. Defendant Avago Technologies U.S. Inc. ("Avago U.S.") is a Delaware corporation headquartered at 1320 Ridder Park Drive, San Jose, California 95131.

13. LSI and Avago U.S. are both wholly owned indirect subsidiaries of holding company Avago Technologies Limited, which is in turn a wholly owned indirect subsidiary of holding company Broadcom Inc. (formerly known as Broadcom Limited).

14. LSI was formed as a result of the merger of LSI Logic Corporation and Agere Systems Inc. ("Agere") in 2007. Avago Technologies Limited then acquired LSI in 2014. The ultimate parent company, Broadcom Inc., was formed as Broadcom Limited on February 1, 2016, as a result of a merger between Avago Technologies Limited and Broadcom Corporation. On March 23, 2018, Broadcom Limited changed its legal name to Broadcom Inc.

15. LSI designs, develops, and supplies storage and networking integrated circuits, including, for example, HDD chips ("HDD Chips"). Defendants' HDD Chips include but are not limited to HDD controller systems-on-a-chip ("SOCs") and/or stand-alone read channel chips, both of which are sold under the TrueStore tradename.

16. Since March 2015, Avago U.S. has handled the U.S. sale and distribution of LSI products, including the product line of SOCs sold under the TrueStore tradename.

17. Defendants undertake "research and development" and "sales and marketing" at their San Jose headquarters. Exhibit 1 (Avago 2015 10-K) at 34.

18. To engage in these activities, at their San Jose headquarters Defendants use HDD Chips and simulators that infringe the Patents, including for testing, performance validation, qualification and demonstrations.

19. Defendants have a "direct sales force focused on supporting large OEMs [original equipment manufacturers]." Exhibit 2 (Broadcom Limited 2017 10-K) at 3.

20. Defendants locate their field application engineers and design engineers "in many cases near [their] top customers" to "enhance [their] customer reach and [their] visibility into new

product opportunities and enable [them] to support [their] customers in each stage of their product development cycle, from early stages of production design through volume manufacturing and future growth." Exhibit 2 (Broadcom Limited 2017 10-K) at 8. This customer outreach and support takes place principally in the United States.

21. Defendants have provided and currently provide customized HDD Chip information, data, simulators, and chips to OEMs—HDD manufacturers—located in this judicial district.

22. Defendants and HDD manufacturer customers make use of Defendants' HDD Chips and simulators, including ones that infringe the Patents, at the customers' facilities located in this district, including for testing, performance validation, qualification and demonstrations. There, Defendants also have provided and currently provide the customers with know-how regarding the inventions of the Patents and support and instructions to implement and operate the inventions of the Patents.

JURISDICTION AND VENUE

23. This is an action for patent infringement arising under the patent laws of the United States, 35 U.S.C. § 271 *et seq*.

24. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331, 1332 and 1338(a).

25. This Court has personal jurisdiction over Defendants because Defendants are headquartered in and regularly conduct business in the State of California and this judicial district. As a result, Defendants have intentionally availed themselves of the privilege of conducting business in this state and district and can reasonably and fairly anticipate being haled into this Court.

26. Venue is proper in this district pursuant to 28 U.S.C. § 1400(b) because Defendants have a regular and established place of business in this district, at least at their headquarters, and have committed acts of infringement in this district, at least at both their headquarters and at the facilities of HDD manufacturer customers.

FACTUAL BACKGROUND

27. Defendants' business includes the design and sale of HDD read channel products, and the methods claimed in the Patents are useful to improve the performance of these types of devices.

A. Exemplary Magnetic Data Storage

28. By way of example, an HDD is a ubiquitous device that stores digital information on one or more rotating disks, also sometimes referred to as "platters," that are coated with magnetic material.

29. Data are stored in sequential, individual magnetically coated regions on the disk by means of controlling the direction of magnetization of each individual region.

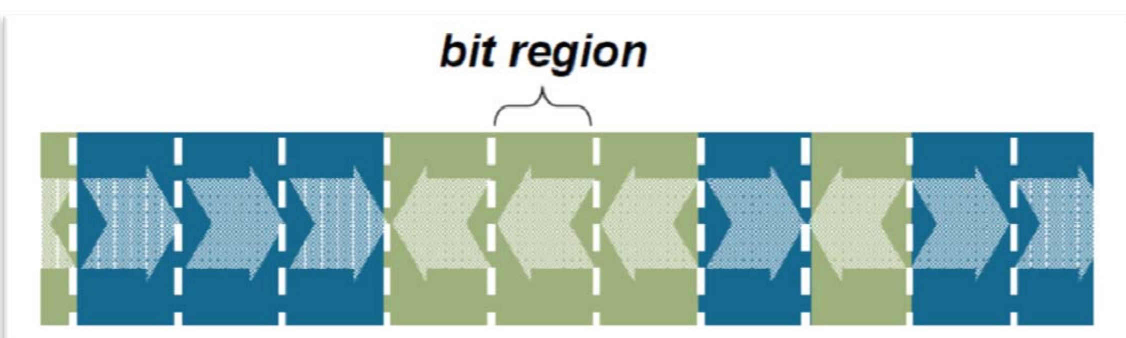
30. An HDD comprises a read/write device that includes both a write head that writes the data to the disk for storage and a read head that subsequently reads the written data when needed.

31. When user data are to be written to the disk, the data are encoded and then the encoded data are converted into an analog signal that is sent to the write head. The write head records the resulting signal on the magnetic disk by magnetically polarizing bit regions on the disk in accordance with the received signal.

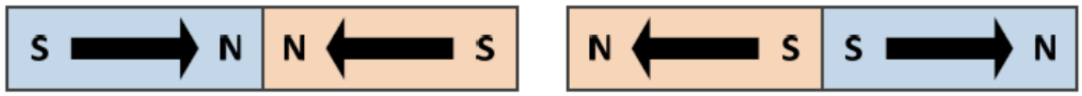
32. Each polarized bit region on the magnetic recording layer of the disk has a magnetic polarization that, once written by the write head, is oriented in a particular direction. The magnetic polarity of these regions can be changed from one direction to its opposite by the write head in order to write the data to the disk.

33. An HDD also includes a read channel that converts the analog data signal generated from the disk of the HDD into binary bits.

34. As shown in the exemplary diagram below, when adjacent polarized bit regions are magnetized in opposing directions (left and right in the diagram below), there is a "transition" in the polarity of the bit regions. The sequence of transitions and nontransitions is detected by the read channel of the HDD when reading the data.



35. There are two different types of transitions - positive and negative. As shown in the diagrams below, a positive transition is where the "north" ends of the polarized bit regions abut, and a negative transition is where the "south" ends abut.



Positive Transition Negative Transition

36. When reading the data from the disk, the read head hovers over the disk as the disk rotates below it. The read head senses the magnetic fields from the magnetic medium and converts the sensed magnetic fields into an analog "readback" signal.

37. A sequence (or data) detector in the read channel converts the analog readback signal into binary data by determining from the signal the likely sequence of transitions and non-transitions recorded to the magnetic medium. For example, in some read channels, detected transitions indicate a binary "1" and a nontransition indicates a binary "0".

38. Readback signals, however, are distorted by noise, which complicates the task of accurately detecting the written data.

39. The detector's challenge is to determine the actual sequence of positive and negative transitions and nontransitions written to the disk despite the noise. Data detection was easier when data density was low because the noise was relatively minor compared to the strength of the readback signal—in technical terms, the "signal-to-noise ratio" (SNR) was sufficiently high.

40. "Data continues to grow, driven by video, social media, enterprise applications and the cloud. To meet this demand, hard drive manufacturers continually drive more capacity per platter in hard drives." *See* https://www.broadcom.com/products/storage/hard-disk-drives/socs-read-channel.

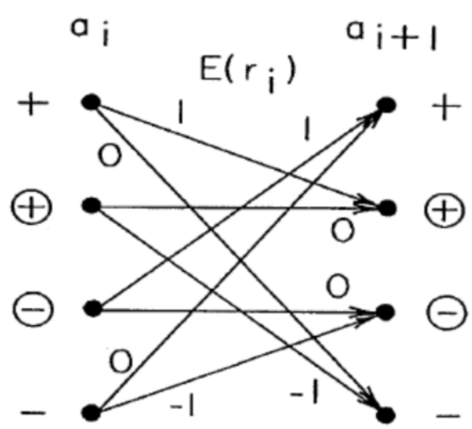
41. Increasing the data capacity of an HDD increases the density of the transitions on the magnetic disk, which in turn increases the amount of noise, in the analog data signal generated by the read head as it passes over the bit regions.

42. To combat this, in the 1990s, the HDD industry migrated to Viterbi (or Viterbi-like) sequence detectors ("Viterbi detectors"). Generally, a Viterbi detector uses a Viterbi algorithm to

translate noise-distorted signal samples of the readback signal into the likely data sequence written to the disk.

43. The Viterbi algorithm uses a trellis whose sequences of branches correspond to possible sequences of data written to the disk. Figure 4 of the Patents shows one section of a trellis. The black circles are "nodes" representing, in this case, two bits of data, e.g., + indicates a positive transition (read as a binary "1") on the disk; ⊕ indicates a non-transition (read as a binary "0") on the disk where the nearest previous transition was positive; ⊖ indicates a non-transition on the disk (read as a binary "0") where the nearest previous transition was negative; and - indicates a negative transition (read as a binary "1") on the disk. In the trellis diagram below, the lines between the nodes on the left and right represent branches of the trellis. Thus, each branch in this diagram represents a three-bit sequence. For example, the branch from + to ⊕ represents the data sequence 010, and so on.

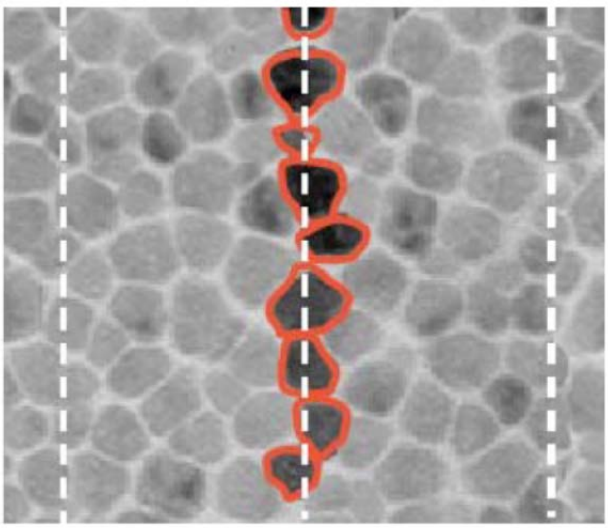
FIG. 4

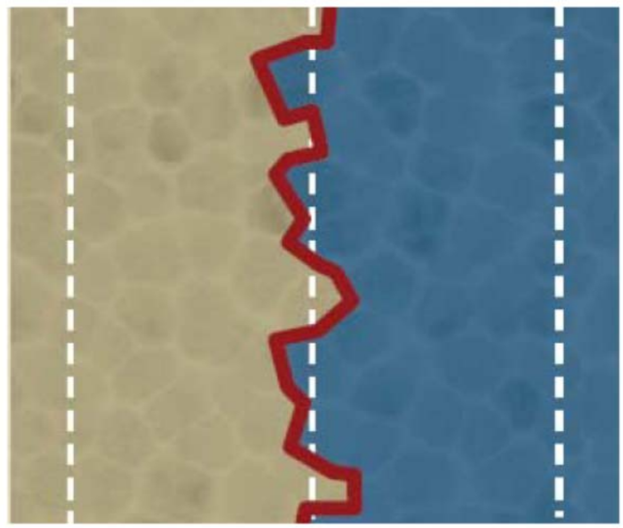


44. Some detectors use a trellis that comprises several of these trellis sections one after another so that it can represent longer sequences of bits. The detector computes a "branch metric value" for some or all of the branches in the trellis, using a branch metric function, and sums the resulting branch metric values for the branches along multiple paths through the trellis to generate a "path metric value" for each such path. The likely sequence of data is usually selected as the one corresponding to the path whose path metric value has the lowest value.

45. Since the early 2000s, noise in the readback signal has continued to increase, particularly "media noise," which is now the dominant factor that limits the detector's ability to accurately read data on the disk.

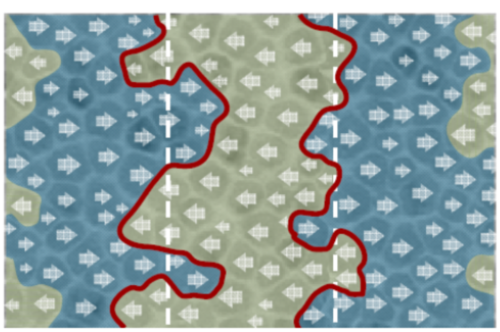
46. One cause of media noise is physical: a hard disk is covered in a mosaic of irregularly shaped magnetic grains that do not align with the ideal, straight, expected boundaries of the bit regions. Thus, the transitions, which the detector has to recognize to detect the binary data, are jagged, as shown in the representations below.



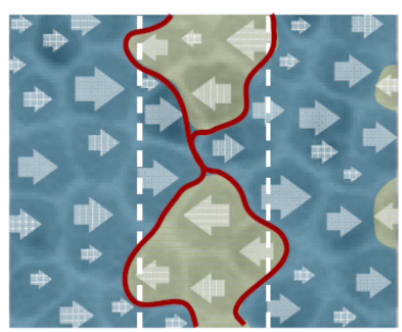


47. As data density increases, which is the overwhelming trend in the HDD industry, the bit regions decrease in size and there are fewer magnetic grains per region. Consequently, the jagged boundaries consume more of the bit region, as shown in the illustrative representations below. This increases the media noise.

Low-to-Moderate Density
(**30-60** grains per bit region)



High Density
(**15-25** grains per bit region)



48. Media noise has two additional complicating factors. First, noise samples are "correlated"; they tend to vary together. For example, the high media noise in the readback signal from a transition (i.e., a change in polarity between adjacent bit regions) ripples through the sequence of samples in the neighborhood so that the samples in the sequence also will tend to have high noise.

49. Second, this correlated media noise is "signal dependent" noise whose structure is attributable to the specific sequence of symbols (or bits) actually written on the disk.

50. An aspect of signal-dependent noise is that the noise in the readback signal samples can be nonlinear. That is, for example, the noise structures from positive transitions are different from the noise structures of negative transitions.

51. Early Viterbi detectors used a single branch metric function that ignored the correlated and signal-dependent attributes of the media noise. As data density increased, this simplistic approach became untenable. Disk manufacturers could not continue to increase data density without more sophisticated detection methods that could accurately read the data despite the increased media noise.

B. The Patents

52. On March 31, 2001, the USPTO issued the '839 Patent, titled "Method and Apparatus for Correlation-Sensitive Adaptive Sequence Detection." A true and correct copy of the '839 Patent is attached as Exhibit 3.

53. On August 20, 2002, the USPTO issued the '180 Patent, titled "Soft and Hard Sequence Detection in ISI Memory Channels." A true and correct copy of the '180 Patent is attached as Exhibit 4.

54. The named inventors for the Patents are Aleksandar Kavcic and José M. F. Moura.

55. When CMU filed the applications that matured into the Patents (application Serial Nos. 09/055,003 and 09/259,195), Dr. Moura was a Professor of Electrical and Computer Engineering at CMU and Dr. Kavcic was Dr. Moura's Ph.D. student.

56. The inventions described in the Patents relate generally to a method of computing branch metric values in a detector, such as a Viterbi detector. The method uses a set of signal

dependent branch metric functions. Further, each signal dependent branch metric function is applied to a plurality of signal sample values as inputs. By using a set of signal-dependent functions with multiple signal sample values as inputs, the detector accounts for the signal-dependent, correlated noise in the readback signal samples, permitting more accurate detection of the written data.

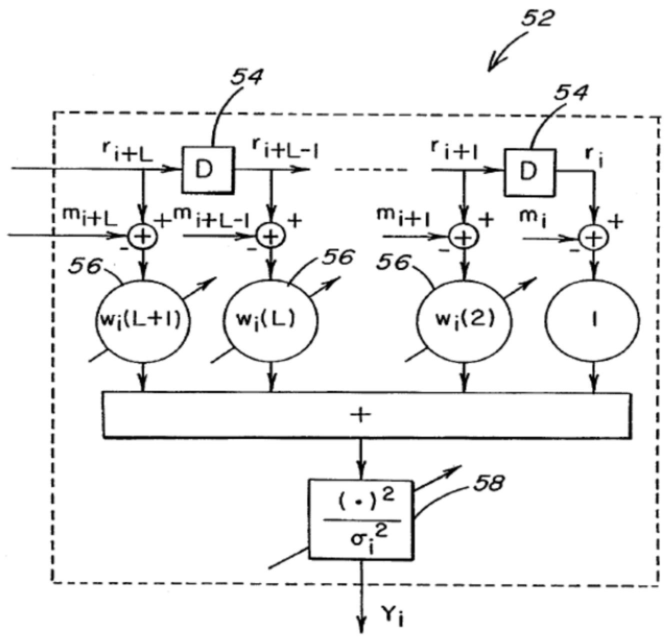
57. The Patents disclose the general set signal-dependent branch-metric functions:

$$M_i = \log\frac{\det C_i}{\det c_i} + \underline{N}_i^T C_i^{-1} \underline{N}_i - \underline{n}_i^T c_i^{-1} \underline{n}_i$$

M_i is the metric for one sequence of symbols, i.e., one trellis branch, and the multiple time variant signal samples are denoted by N_i and n_i (where n_i is a subset of N_i). The Patents teach tuning the parameters, i.e., C_i and c_i (where c_i is a sub-portion of C_i), for different branches of the trellis to make up the set of signal-dependent branch metric functions.

58. As shown in the example from Figure 3B of the Patents, reproduced below, the Patents disclose how the inventive signal-dependent branch metric functions can be implemented in hardware with so-called finite impulse response (FIR) filters. In this figure, which shows the FIR filter for one of the signal dependent branch metric functions, the multiple signal samples are shown as inputs r_{i+L}, r_{i+L-1}, …, r_{i+1}, r_i. Each signal sample is multiplied by a tap weight, indicated by the circles 56, with the corresponding weights for each sample denoted as $w_i(L+1)$, $w_i(L)$, …, $w_i(2)$, and 1.

FIG. 3B



59. The weights of the FIR filter can be (and typically are) different for different branches of the Viterbi trellis to implement, if desired, a different signal dependent branch metric function for each branch. In particular, since a specific branch of a Viterbi trellis corresponds to a specific possible pattern or sequence of data, the weights of the FIR filters can be tuned to account for the signal-dependent structure of the noise for each corresponding branch.

60. For that reason, the FIR filters of Viterbi detectors that implement the patented methods are often referred to in the industry as "pattern-dependent FIRs" or "data-dependent FIRs," and detectors that include such pattern-dependent or data-dependent FIRs are referred to as "non-linear detectors," since they account for the nonlinearities in the media noise.

61. The invention of the Patents "represents a substantial advance over prior sequence detectors" because it "takes into account the correlation between noise samples in the readback signal," which allows the data sequence being read by the read head to be "detected with a higher degree of accuracy." '180 Patent at col. 2:35-39. Also, the claimed inventions of the Patents are different from and superior to prior art detectors because the claimed inventions of the Patents account for the signal-dependent nature of the correlated noise.

62. Claim 4 of the '839 Patent claims "[a] method of determining branch metric values

for branches of a trellis for a Viterbi-like detector, comprising: selecting a branch metric function for each of the branches at a certain time index from a set of signal-dependent branch metric functions; and applying each of said selected functions to a plurality of signal samples to determine the metric value corresponding to the branch for which the applied branch metric function was selected, wherein each sample corresponds to a different sampling time instant." '839 Patent at col. 14:10-19.

63. Claim 1 of the '180 Patent claims "[a] method of determining branch metric values in a detector, comprising: receiving a plurality of time variant signal samples, the signal samples having one of signal-dependent noise, correlated noise, and both signal dependent and correlated noise associated therewith; selecting a branch metric function at a certain time index; and applying the selected function to the signal samples to determine the metric values." '180 Patent at col. 15:39-48.

64. Claim 2 of the '180 Patent claims the method as in claim 1 "wherein the branch metric function is selected from a set of signal-dependent branch metric functions." '180 Patent at col. 15:49-51.

65. These three claims describe inventions that improve a physical process by overcoming limitations in physical devices. The methods cannot be performed mentally or with pencil and paper because the claims require that the methods be performed in a detector and because the human mind cannot possess noisy signal samples and, therefore, cannot apply functions to noisy signal samples.

66. Specifically, the claimed inventions improve the sequence detector in a read channel in an HDD by enabling the detector to discern more accurately what is written on the magnetic recording medium, which is tied to what the read head has sensed.

67. On January 21, 2014, Ropes & Gray filed *ex parte* reexamination requests with the USPTO for claim 4 of the '839 Patent and claims 1 and 2 of the '180 Patent.

68. On October 29, 2014, the USPTO confirmed the patentability of claim 4 of the '839 Patent without amendment. A copy of the Ex Parte Reexamination Certificate for the '839 Patent is provided as Exhibit 5 hereto.

69. On January 30, 2015, the USPTO confirmed the patentability of claims 1 and 2 of the ’180 Patent without amendment. A copy of the Ex Parte Reexamination Certificate for the ’180 Patent is provided as Exhibit 6 hereto.

70. CMU is the owner and assignee of all right, title, and interest in and to the Patents and holds the right to sue and recover damages for infringement thereof, including past damages.

C. The *CMU v. Marvell* Case

71. In 2009, CMU filed a complaint for infringement of the Patents against Marvell Technology Group, Ltd. and Marvell Semiconductor, Inc. (collectively, “Marvell”), a principal competitor of Defendants in the HDD read channel market, in the United States District Court for the District of Western Pennsylvania, Case No. 2:09-cv-00290-NBF.

72. On December 26, 2012, the jury returned a verdict in CMU’s favor, finding, among other things, that all of the accused Marvell HDD Chips and simulators directly and indirectly infringed both claim 4 of the ‘839 Patent and claim 2 of the ‘180 Patent, and awarding CMU approximately $1.17 billion in damages as a reasonable royalty for Marvell’s unauthorized use of CMU’s patented methods.

73. The jury also found that Marvell had not proven that claim 4 of the ’839 Patent and claim 2 of the ’180 Patent were invalid.

74. Post-trial, among other things, the district court denied Marvell’s motions for judgment as a matter of law (“JMOL”) or new trial on invalidity, non-infringement and damages.

75. On appeal, in August 2015, the United States Court of Appeals for the Federal Circuit affirmed the district court’s denial of Marvell’s motions for JMOL or new trial on invalidity and non-infringement. The Federal Circuit remanded the case for a partial new trial on damages. *See Carnegie Mellon Univ. v. Marvell Tech. Group, Ltd.*, 807 F.3d 1283 (Fed. Cir. 2015).

76. In connection with the appeal, on August 11, 2014, Broadcom Corporation (now a member of the Broadcom Inc. family of companies, along with Defendants) filed an amicus curiae brief, with other joint amici, supporting Marvell.

77. Post-appeal, CMU and Marvell settled the case in February 2016 with Marvell agreeing to pay CMU $750 million. *See, e.g.*, www.reuters.com/article/us-marvell-technlgy-

carnegiemellon-idUSKCN0VQ2YE and www.wsj.com/articles/marvell-to-pay-750-million-in-settlement-with-carnegie-mellon-1455746246?mg=id-wsj.

78. The *CMU v. Marvell* case, which lasted over six years, was reported extensively by the media and was widely known in the HDD industry.

D. Defendants' Unauthorized Use of the Methods Claimed in the Patents

79. Defendants make, use, and sell HDD read channel devices that implement the invention claimed in the Patents, including HDD Chips sold under the tradename TrueStore ("Accused Chips") and computer-implemented detectors that execute simulation code files to apply a set of branch metric functions to actual readback signal samples ("Simulators") (the Accused Chips and Simulators are collectively the "Exemplary Accused Products"). Exemplary Accused Products in the TrueStore product line include but are not limited to the RC5101 Spyder ELP PS Azure, the RC5110 Sypder ELP PS Boxster, and the RC5200 Spyder ELP PS Corvette read channels and SOCs that include those read channels.

80. A current senior engineering executive of Defendants has admitted that LSI uses the invention claimed in the Patents.

81. Dr. Yuan Xing Lee was an LSI Vice President from 2007 to 2014. He subsequently served as a "Vice President of Engineering for the Data Controller Division at Broadcom" and is now "Vice President & Head of Central Engineering in Broadcom Limited." *See* www.linkedin.com/in/yuan-xing-lee-5906225.

82. A true and correct redacted copy of Dr. Lee's LinkedIn page dated July 18, 2018, is attached as Exhibit 7.

83. In late 2009, while Prof. Kavcic was visiting an LSI facility in California, Dr. Lee told Prof. Kavcic that LSI used Prof. Kavcic's "detector."

84. Dr. Shaohua Yang, then an LSI engineer and a former student of Prof. Kavcic, was present for this conversation.

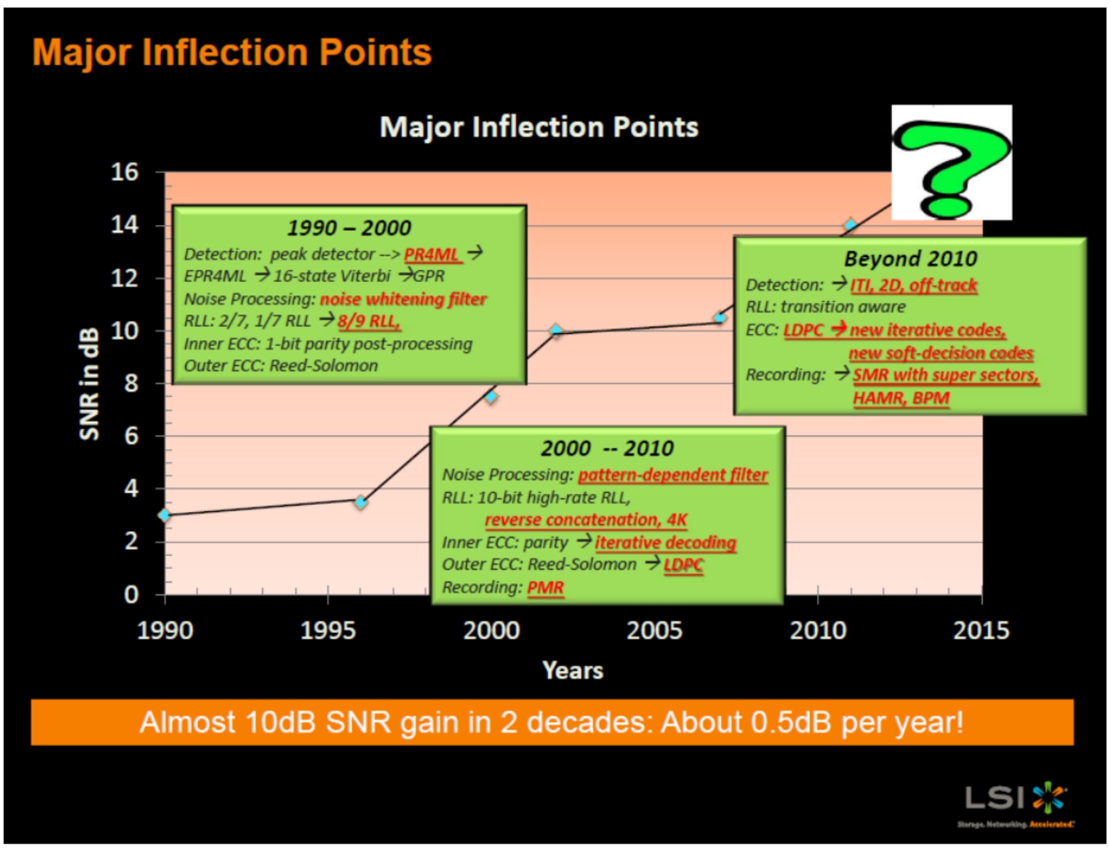
85. On September 20, 2010, in an email to Prof. Kavcic, Dr. Lee wrote that "we [LSI] cannot run channels w/o Kavcic's DDNP algorithms." As his email signature indicated, Dr. Lee was then a member of LSI's "Channel IP Development" team.

86. Dr. Lee copied Dr. Haitao (Tony) Xia on that email. Dr. Xia was a Principal Engineer of Read Channel Architecture at LSI from 2009 to 2011, and subsequently served as the Senior Manager, Read Channel Architecture at LSI and Senior Manager and then Director of Data Storage System Architecture at "Avago Technologies." *See* www.linkedin.com/in/haitao-tony-xia-53412322.

87. In addition to Dr. Lee's verbal and written admissions to Prof. Kavcic, Dr. Lee gave a presentation in 2012 at the Chinese American Information Storage Society ("CAISS") Annual Conference titled "Read Chanel [*sic*] Technologies for Data Storage."

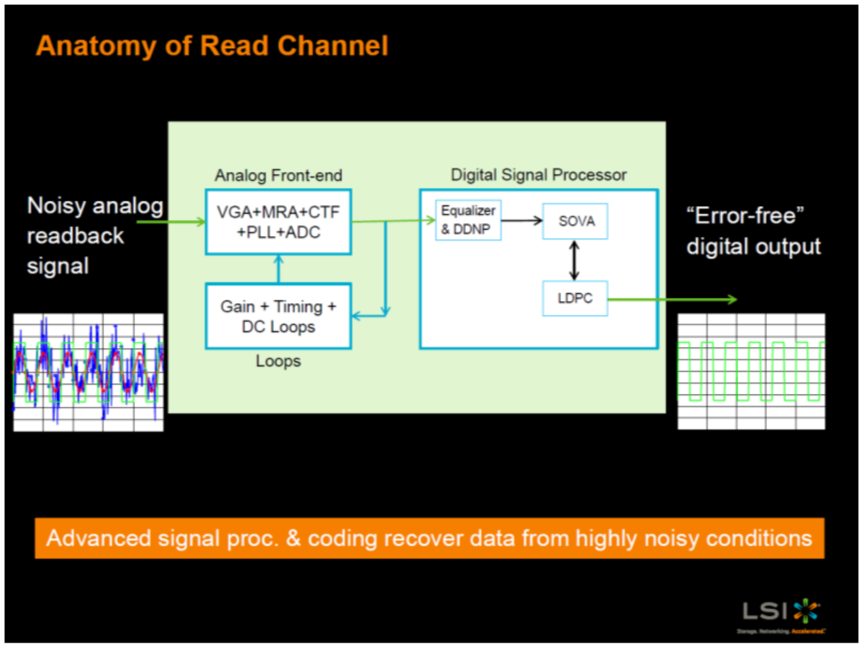
88. A true and correct copy of the slides for Dr. Lee's presentation to CAISS at its 2012 annual conference is attached as Exhibit 8.

89. In Slide 6 of his presentation, shown below, Dr. Lee identified "pattern-dependent filter" as a "major" technology for "noise processing" in the 2000-2010 period.



90. "Pattern-dependent filter" in this context in the industry refers to a set of FIR filters that is used to implement a set of signal-dependent (or "pattern-dependent") branch metric functions, which is covered by the Patents.

91. In Slide 5 of his presentation, shown below, Dr. Lee showed a block diagram of a read channel that includes, in the "digital signal processor" section, a block titled "Equalizer & DDNP."



92. In this slide, "DDNP" refers to "data dependent noise prediction," an industry term for a set of signal-dependent branch metric functions, which are claimed by the Patents.

93. In fact, numerous patents and applications assigned to the Broadcom Inc. family of companies, of which Defendants are a part, also use terms like "DDNP," "data dependent noise prediction," "signal-dependent" and "NPFIR" (*e.g.* noise predictive FIR filter), to refer to the invention claimed in the Patents as an important read channel component. *See* Exhibit 9.

94. The LinkedIn pages of several former LSI engineers confirm that Defendants implemented the methods of the Patents. Dr. Nenad Miladinovic, a "Senior ASIC Design Engineer" at LSI from 2008 to 2010, states on his LinkedIn profile page that at LSI he "[i]mprov[ed] DDNP BCJR implementation." *See* www.linkedin.com/in/nenad-miladinovic-9287726. Dongyan Jiang's LinkedIn page says that he "Defined and Implemented DDNP (Data-Dependent Noise Prediction) FIR filter and Viterbi" while at LSI from 2000-2007. *See* www.linkedin.com/in/dongyan-jiang-

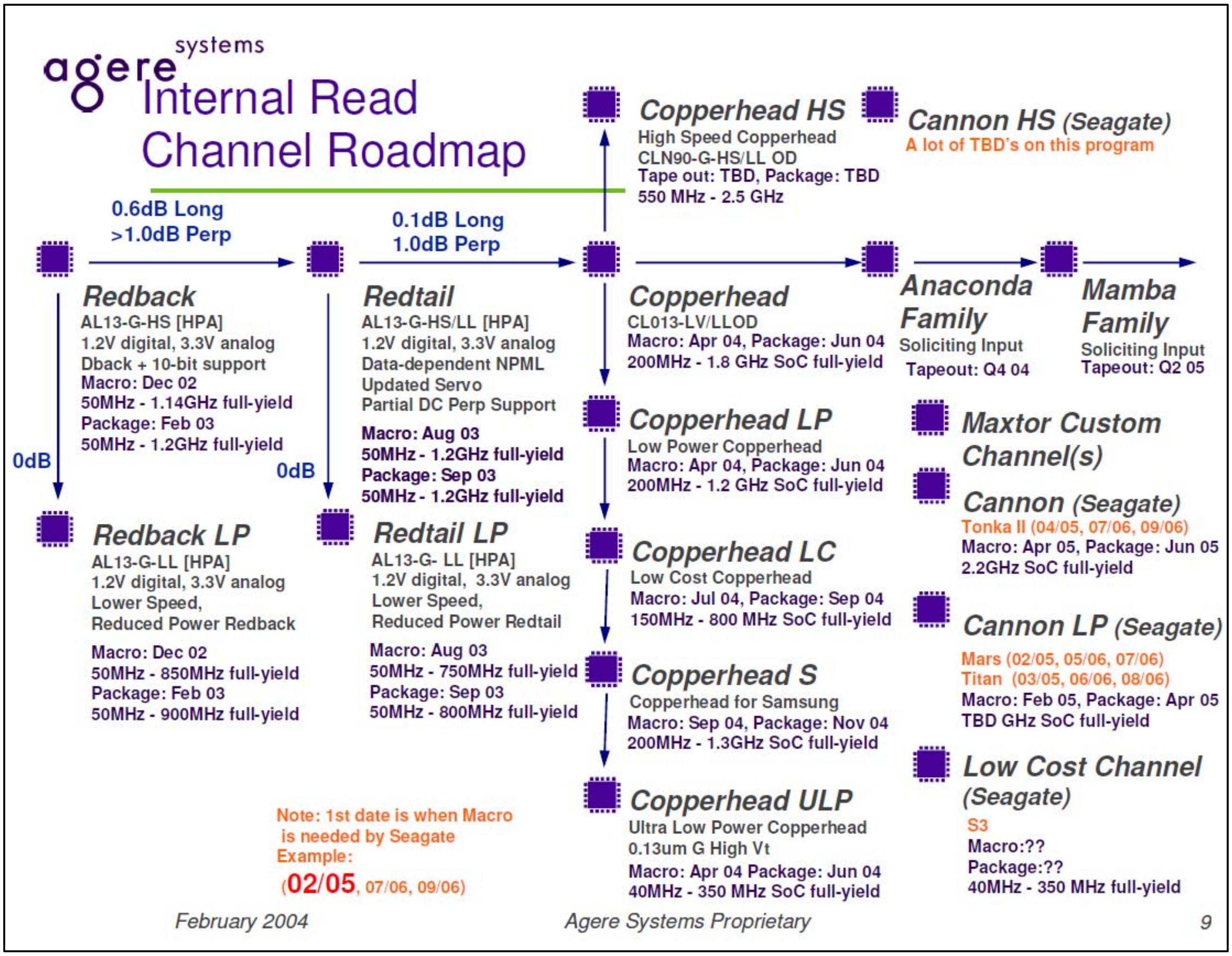
a96aa912/. Similarly, Weijun Tan's LinkedIn page says that he "developed … data dependent noise prediction filter" while at LSI from 2004-2017. *See* www.linkedin.com/in/weijun-tan-7082064/.

95. "BCJR" is a type of soft-output Viterbi algorithm described in the '180 Patent. *See* '180 Patent at col. 14:8-12.

96. Defendants' publicly available product specification shows that one or more of the Exemplary Accused Products has data-dependent noise-predictive FIRs that implement the methods claims in the Patents.

97. Exhibit 10 is a true and correct copy of a slide presentation recently made available on the Internet at www.scribd.com/document/367470390/read-channel-overview-part-1, entitled "Read Channel Market and Roadmap" from Agere, a predecessor of LSI, dated February 2004.

98. Page 9 of this presentation, shown below, is an "internal read channel roadmap" that shows that Agere introduced "Data-dependent NPML" in its "Redtail" read channel in around September 2003. In this context, "Data-dependent NPML" refers to data-dependent noise prediction maximum likelihood, an industry term for a set of signal-dependent branch metric functions, which are claimed by the Patents.



99. HDD industry practice is that when one supplier adopts a useful or beneficial technology, competing suppliers also adopt that technology to compete against the first adopter with their HDD manufacturer customers.

100. Because Marvell, a significant competitor of Defendants in the HDD Chip design market, adopted and commercialized the inventions claimed in the Patents beginning in 2001, Defendants also did so to keep pace with the competition.

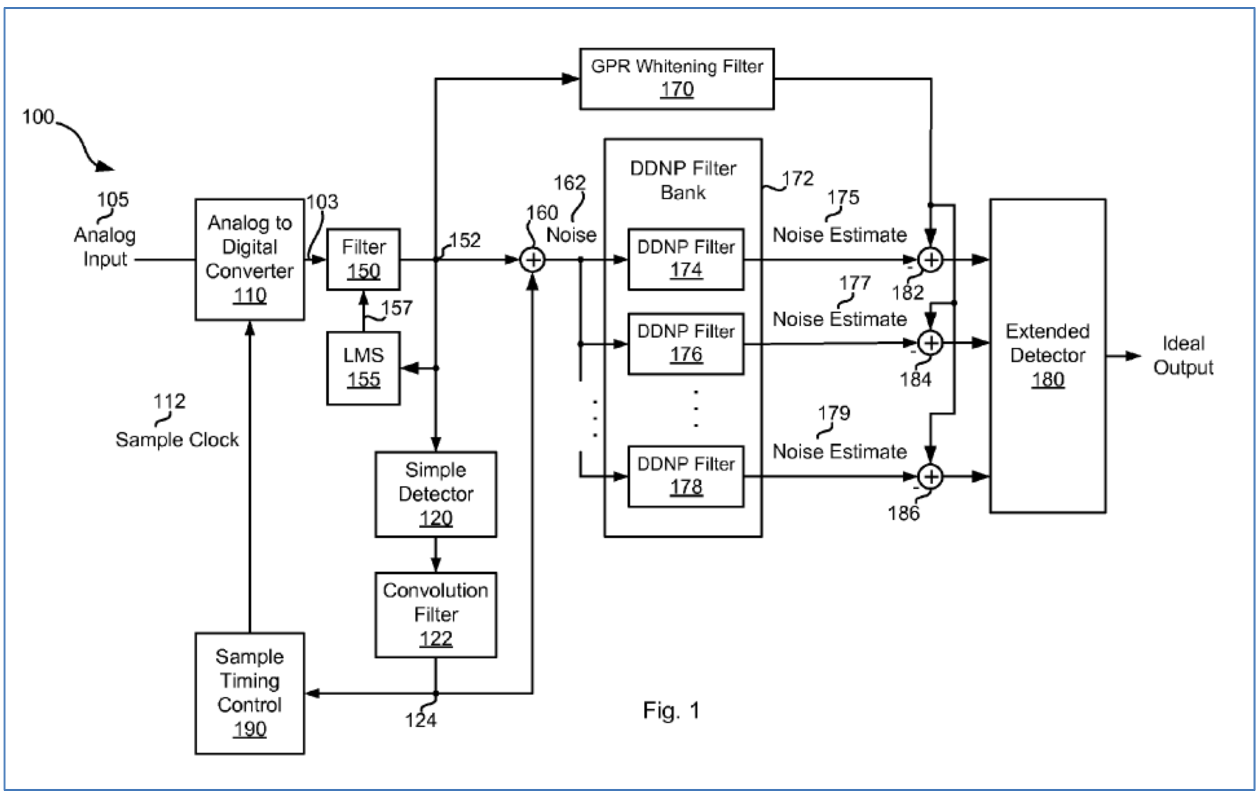
101. Further evidence of the industry-wide adoption of the Patents is provided in published U.S. patent application Pub. No. 2008/0192378, filed January 31, 2008, a true and correct copy of which is provided as Exhibit 11. This application was originally assigned to Broadcom Corporation and was subsequently assigned to Avago Technologies General IP (Singapore) Pte. Ltd. in 2017.

102. This published application explains, without qualification, that "in order to optimize

the performance of [a] sequence detector" in an HDD, "data-dependent noise predictive (DDNP) filters (often referred to as whiteners) and data-dependent bias compensation terms are used in Viterbi branch metric calculation." Exhibit 11 at ¶ [0039].

103. This application further describes that a "DDNP filter bank" and "DDNP Viterbi branch metric calculation module" perform the "Viterbi branch metric calculation." *Id.* at ¶ [0040].

104. Still further, Figure 1 of published U.S. patent application Pub. No. 2010/0067621, assigned to LSI Corporation, a true and correct copy of which is provided as Exhibit 12, shows a bank of DDNP filters, as shown below, where each DDNP filter is "tuned to a respective, defined data pattern" and "estimate[s] the noise correlation for specific data patterns." Exhibit 12 at ¶¶ [0022]-[0023]. In other words, each DDNP is part of the implementation of a specific signal-dependent branch metric function. Further, this patent (Exhibit 12) explains that each of the DDNP filters "operates as a de-correlation filter that de-correlates the noise component of the received signal." *Id.* at ¶ [0022].



105. Similarly, U.S. Patent No. 8,873,182, originally assigned in 2012 to LSI Corporation and subsequently assigned to Avago Technologies General IP (Singapore) Pte. Ltd. in 2014, a true and correct copy of which is attached as Exhibit 13, describes "a noise predictive finite impulse response (NPFIR) filter bank 214 to perform noise predictive filtering." Exhibit 13 at col. 5:65 to col. 6:1. To provide information on how to implement such noise predictive filtering, the patent cites to a paper co-authored by Prof. Kavcic, *see id.* at col. 6:4-10, specifically Kavcic et al., "A Signal-dependent Autoregressive Channel Model", *IEEE Transactions on Magnetics*, Vol. 35, September 1999, pp. 2316-2318, a true and correct copy of which is provided as Exhibit 14. This paper is incorporated "by reference for all purposes" into the patent that is Exhibit 13. *See* Exhibit 13 at col. 6:5-10. The incorporated Kavcic paper describes the inventions of the Asserted Claims, including how to implement a "bank of 'whitening' FIR filters" for computing branch metrics in a sequence (Viterbi) detector. Exhibit 14 at 2318.

106. Banks of data-dependent noise predictive filters, such as those described in Exhibits 11, 12 and 13, are used in the Viterbi branch metric calculations designed by Defendants and used in their TrueStore line of Exemplary Accused Products.

107. Each data-dependent noise predictive filter described in Exhibits 11, 12 and 13, and used in Defendants' TrueStore line of Exemplary Accused Products, has multiple taps, each for a separate time variant sample from the readback signal, and implements a signal-dependent branch metric function—one that is "tuned to a respective, defined data pattern"—such that the bank of data-dependent noise predictive filters implement a set of signal-dependent branch metric functions that are applied to multiple time-variant signal samples.

108. Defendants have designed, tested, and used the Exemplary Accused Products in the United States in a manner that performs the methods described in one or more method claims of the Patents, including but not limited to claim 4 of the '839 Patent and claim 2 of the '180 Patent.

109. When reading data, Defendants' Exemplary Accused Products perform the methods of claim 2 of the '180 Patent and claim 4 of the '839 Patent millions of times per second.

110. Defendants provide HDD Chips and Simulators to customers that include HDD manufacturers. Defendants provide these Chips and Simulators to HDD manufacturers in the United

States for, among other purposes to convince the HDD manufacturers to buy the chips in large quantities and to help optimize the performance of the chips in the HDD manufacturers' HDDs. To demonstrate the performance of Defendants' chips, Defendants operate the Exemplary Accused Products with and for their HDD customers in the United States as part of the design, development, testing and qualification stages for the sale of Defendants' HDD read channel chips.

111. Defendants have provided to customers HDD Chips and Simulators that use the invention claimed in the Patents.

112. At Defendants' direction, Defendants' HDD manufacturer customers have operated the HDD Chips and Simulators provided by Defendants in the United States.

113. Defendants' HDD manufacturer customers have operated the HDD Chips and Simulators, including the Exemplary Accused Products, at Defendants' direction in the United States in a manner that performs the methods described in one or more method claims of the Patents, including claim 4 of the '839 Patent and claim 2 of the '180 Patent.

114. Defendants' Exemplary Accused Products, when operated in the United States by Defendants, their customers, or end users (who purchase Defendants' customers' HDD products incorporating the Exemplary Accused Products), as the case may be, determine branch metric values in a detector (including, e.g., a Viterbi-like detector) by:

- Receiving a plurality of time variant samples, e.g., signal samples of the readback signal, that inherently have signal-dependent, correlated noise;
- Selecting a branch metric function from a set of signal dependent branch metric functions corresponding to the branch of the trellis at a certain time index; and
- Applying the selected signal dependent branch metric function to the plurality of signal samples to determine the branch metric value of the branch for which the applied branch metric value was selected.

115. Defendants' Exemplary Accused Products can be and are programmed by Defendants or at Defendants' direction to determine branch metric values in a detector (including, *e.g.* a Viterbi-like detector) by:

- Receiving a plurality of time variant samples, e.g., signal samples of the readback signal, that inherently have signal-dependent, correlated noise;
- Selecting a branch metric function from a set of signal dependent branch metric functions corresponding to the branch of the trellis at a certain time index; and
- Applying the selected signal dependent branch metric function to the plurality of signal samples to determine the branch metric value of the branch for which the applied branch metric value was selected.

116. Defendants direct, instruct, and assist their HDD manufacturer customers regarding the use of the Exemplary Accused Products such that when operated, the Exemplary Accused Products determine branch metric values in a detector (including, e.g., a Viterbi-like detector) by:

- Receiving a plurality of time variant samples, e.g., signal samples of the readback signal, that inherently have signal-dependent, correlated noise;
- Selecting a branch metric function from a set of signal dependent branch metric functions corresponding to the branch of the trellis at a certain time index; and
- Applying the selected signal dependent branch metric function to the plurality of signal samples to determine the branch metric value of the branch for which the applied branch metric value was selected.

117. Defendants direct, instruct, and assist their HDD manufacturer customers to use the Exemplary Accused Products in an infringing manner through documentation, including product specifications, user guides, and register maps, which provides instructions to the customers on how to operate the Exemplary Accused Products in an infringing manner.

118. Defendants' HDD customers in fact do operate the Exemplary Accused Products in an infringing manner.

119. For example, among other things, the Exemplary Accused Products have firmware through which the invention claimed in the Patents is enabled. When the invention is enabled, the Exemplary Accused Products perform the methods claimed in the Patents. Defendants provide verbal and written instructions to engineers of Defendants' HDD manufacturer customers to enable the invention in the Exemplary Accused Products through firmware and provide Exemplary Accused Products to Defendants' HDD manufacturer customers with the invention enabled through the firmware.

120. Upon information and belief, the written instructions for enabling the invention provided by Defendants to the engineers of its HDD manufacturer customers include, among other things, register maps that instruct customers to program the firmware of the Exemplary Accused Products so that the invention is enabled.

121. Defendants are aware that enablement of the invention improves the performance of the Exemplary Accused Products, and Defendants intend for both they and their customers to make use of the performance gains resulting from use of the invention. Accordingly, Defendants, or their customers on instruction from Defendants, enable the invention and leave it enabled to take advantage of that improved performance. Defendants further specifically intend that both they and their customers infringe at least claim 4 of the '839 Patent and claim 2 of the '180 Patent.

122. Defendants' customers in fact program the Exemplary Accused Products so as to practice the method of claim 4 of the '839 Patent and the method of claim 2 of the '180 Patent.

123. Defendants also direct, instruct, and assist their HDD manufacturer customers in operating Exemplary Accused Products in an infringing manner through meetings, phone calls, and emails between Defendants' engineers and Defendants' HDD manufacturer customers' engineers, in which Defendants' engineers provide technical briefings, demonstrate the benefits of the invention, and instruct the customer's engineers about how to use the Exemplary Accused Products in an infringing manner with the specific intent that they do so, such as by enabling the invention in the firmware.

124. Defendants' customers in fact enable the method of claim 4 of the '839 Patent and the method of claim 2 of the '180 Patent in the Exemplary Accused Products, and Defendants are aware that the Exemplary Accused Products are so enabled.

125. Defendants provide their HDD manufacturer customers with HDD Chips that are enabled with the invention such that when operated the HDD Chips infringe method claims of the Patents.

126. The components of the read channel in Defendants' Exemplary Accused Products that implement the invention are specifically designed to perform the methods claimed in the Patents, and Defendants intend that these components be so used.

127. The components of the read channel in Defendants' Exemplary Accused Products that apply the selected signal dependent branch metric functions to multiple time variant samples from the readback signal in order to compute branch metric values for branches of a trellis of a detector cannot be used in a non-infringing manner.

128. The read channels in the Accused Chips include a detector with FIR filters that are used to compute branch metric values. Defendants specifically designed these FIR Filters to perform the steps of claim 4 of the '839 Patent and claim 2 of the '180 Patent, and have no substantial use other than to perform the methods of those claims.

129. One performance metric for a read channel is the bit error rate ("BER"), which is the rate at which the read channel makes errors in determining the data written to the disk.

130. Defendants' HDD manufacturer customers enable the read channels products designed by Defendants to practice the methods claimed in the Patents because of the improved BER performance that it provides, which is crucial to the Defendants' HDD manufacturer customers.

131. Because Marvell's and Defendants' customers include the same HDD manufacturers, Defendants must provide the same competitive infringing technology that Marvell provides, and Defendants are aware of these facts.

E. Defendants' Sales Cycle for the Exemplary Accused Products

132. Defendants have engaged and continue to engage in an extensive design, development, and sales cycle ("Sales Cycle") to sell, for example, their HDD Chips.

133. The Sales Cycle is "typically lengthy" and requires Defendants "dedicate significant development expenditures and scarce engineering resources in pursuit of a single customer opportunity." Exhibit 2 (Broadcom Limited 2017 10-K) at 17.

134. The Sales Cycle "involves a significant investment of money, time, and effort on the part of both the chip supplier and the OEM," e.g., Western Digital, Toshiba, Seagate and HGST. *See* Pl. Mem. In Supp. of Mot. For Entry of Prelim. Inj. at 8, Broadcom Corp. v. Emulex Corp., No. SACV09-1058 JVS (ANx) (C.D. Cal. Jan. 18, 2012).

135. During this Sales Cycle, Defendants work closely with potential customers to optimize and customize the technologies Defendants have designed to use in their HDD Chips for incorporation into customers' HDD products. "By collaborating with [their] customers, [Defendants] have opportunities to develop high value-added, customized products for them …." Exhibit 2 (Broadcom Limited 2017 10-K) at 8.

136. During the Sales Cycle, Defendants use their HDD Chips and simulators both at their own U.S. facilities and at the U.S. facilities of their HDD manufacturer customers. Such domestic use includes extensive testing, performance validation, qualification, and demonstrations of the HDD Chips and simulators.

137. Defendants instruct and encourage their HDD manufacturer customers to extensively test, evaluate, validate, and qualify Defendants' HDD Chips and simulators throughout the Sales Cycle in the United States.

138. Defendants' "business is dependent on [their] winning competitive bid selection processes, known as 'design wins. Exhibit 2 (Broadcom Limited 2017 10-K) at 17.

139. "Design wins are not simply sale-by-sale decisions; rather, they represent the culmination of a process that includes multiple stages and carries with it ramifications that can last for years." *See* Br. of Pl.-Appellee Broadcom Corp. at 52, Broadcom Corp. v. Emulex Corp., No. 2012-1309 (Fed. Circ. July 26, 2012).

140. As LSI's CEO explained in May 2013: "We measure our performance, our traction with our customers based on the value that we can enable them to provide to their customers. And so we measure that oftentimes in terms of design wins. We've just come off the end of the year once

again measuring record levels in terms of the design wins that we've captured. We typically measure this in terms of 3 years worth of revenue generated from specific designs with specific customers." "LSI Corporation Presents at Goldman Sachs Technology & Internet Conference 2013, Feb-12-2013 02:00 PM," Seeking Alpha, February 13, 2013, available at http://seeking alpha.com/article/1190841-lsi-corporation-presents-at-goldman.

141. Design wins are awarded before volume productions.

142. Read channel SoC pricing is determined at the time of the design win.

143. For example, during LSI's October 2008 earnings call, Abhijit Tawalkar, LSI's CEO, stated "Actually, we haven't seen that [pricing pressure on the component side] in the ASP pressure in our space, and how we've explained in the past, we have volume pricing agreements with our customers that's spend [sic-that span] multiple quarters, and typically the pricing and pricing negotiation occurs at the onset of new design wins that open up, not in the life of a particular SOC when it's in production." "LSI Corporation Q3 2008 Earnings Call Transcript," Seeking Alpha, October 22, 2008, at p. 10 of 15, available at http://seekingalpha.com/article/101317lsicorporationq32208earningscalltranscript? Part=single.

144. Use of the HDD Chips and Simulators by both Defendants and their HDD manufacturer customers during the Sales Cycle results in lucrative "design wins" with Defendants' HDD manufacturer customers, such that Defendants' domestic uses of the methods of claim 4 of the '839 Patent and claim 2 of the '180 Patent during the Sales Cycle are particularly valuable.

145. Defendants' "design wins" in the United States result in sole source agreements with customers for Defendants' HDD Chips that are the subject of each "design win," such that the "design wins" constitute sales of the HDD Chips in the United States.

146. In addition to and as part of the U.S. "design wins" that constitute the sales of Defendants' HDD Chips, substantial activities of these sales transactions occur in the United States, including Defendants' marketing, design, and testing of HDD chips, meetings with Defendants' HDD manufacturer customers, and the delivery of HDD Chip samples to those customers for evaluation.

147. Without Defendants' and their HDD manufacturer customers' U.S.-based use of the HDD Chips during the Sales Cycle, Defendants would not have achieved critical design wins (i.e., sales), would not have shipped hundreds of millions of their HDD Chips to customers, and would not have obtained the resulting profits.

148. Defendants use and sell all of their Exemplary Accused Products through this Sales Cycle.

149. During the Sales Cycle, Defendants, through use of the Exemplary Accused Products, perform the methods of Claim 4 of the '839 Patent and Claim 2 of the '180 Patent.

150. During the Sales Cycle, Defendants instruct and encourage their HDD manufacturer customers to use the Exemplary Accused Products in modes that practice one or more methods claimed in the Patents with the intent that such customers will purchase Exemplary Accused Products for use in the customers' HDD products in infringing modes.

151. The BER performance gain provided by infringing use of Defendants' Exemplary Accused Products was necessary for Defendants to secure design wins with their HDD manufacturer customers.

F. Defendants' Knowledge of the Patents

152. Defendants have had knowledge of the Patents since at least August 5, 2003.

153. CMU notified Agere, LSI's direct predecessor, of the Patents on August 5, 2003 through letters to two Agere executives, John Dickson and Jean Rankin. The letters specifically identified the Patents by patent number, provided information regarding the claimed invention, and offered Agere a license to the Patents.

154. At the time Mr. Dickson received the letter, he was Agere's President and CEO.

155. At the time Ms. Rankin received the letter, she was Agere's Executive Vice President, General Counsel and Secretary. After LSI Logic Corporation and Agere merged to form LSI in 2007, Ms. Rankin served as Executive Vice President, General Counsel and Secretary of LSI until 2014, including during the time that LSI was infringing the Patents.

156. Agere responded to CMU's August 5, 2003 letters by declining to license the Patents on the basis of "resource limitations" that purportedly prevented Agere from "investigat[ing] and evaluat[ing] the benefits of patents such as those from Carnegie Mellon."

157. At least one senior executive of the Defendants, Dr. Lee, had knowledge of the Patents and Defendants' infringement of them from at least 2009.

158. Dr. Lee, LSI Vice President from 2007 to 2014, communicated his knowledge of the Patents and Defendants' infringement to Prof. Kavcic, a named inventor of the Patents, at least twice.

159. In late 2009, at a meeting at an LSI facility in California, Dr. Lee told Prof. Kavcic that LSI uses "your detector."

160. Dr. Yang, who was present for Dr. Lee's admission of infringement, was a former student of Prof. Kavcic's and a named inventor on U.S. Patent No. 8,854,755, which cites the '839 Patent.

161. In a September 20, 2010 email, Dr. Lee again told Prof. Kavcic that "we [LSI] cannot run channels w/o Kavcic's DDNP algorithms."

162. The Defendants are also aware of the Patents and their use of the methods claimed in the Patents based on the prosecution history of several of their patents.

163. At least three patents initially assigned to LSI cite the '839 Patent: U.S. Patent Nos. 8,046,666; 8,792,195; and 8,854,755.

164. For U.S. Patent No. 8,792,195, LSI cited the '839 Patent in the Information Disclosure Statement it submitted to the USPTO on January 16, 2014.

165. During the prosecution of U.S. Patent No. 8,046,666, on February 15, 2011, the Examiner issued a non-final rejection of the claims as unpatentable over the '839 Patent.

166. At least one patent initially assigned to LSI, U.S. Patent. No. 8,713,495, cites the '180 Patent. Specifically, LSI cited the '180 Patent in the Information Disclosure Statement it submitted to the USPTO on April 12, 2013.

167. Several patents initially assigned to LSI's predecessors in interest, LSI Logic Corporation and Agere, also cite to the Patents, including U.S. Patent Nos. 7,002,890; 6,751,774; 6,606,728; 6,570,919; and 6,480,984.

168. Upon information and belief, Defendants also became aware of the Patents and their infringement as a result of their knowledge of the *CMU v. Marvell* case, which was extensively covered by the media and was widely known in the industry.

169. The *CMU v. Marvell* case received wide notoriety, with articles about the trial, appeal and reexaminations appearing at various times in numerous news periodicals and websites, including the Wall Street Journal, New York Times, San Jose Mercury News, the San Francisco Chronicle, Reuters, and Bloomberg, on legal news websites, such as IPLaw360, American Lawyer, and Corporate Counsel, and on technical news websites, such as the EETimes. Several of these articles contained the numbers of the patents in suit.

170. Because the *CMU v. Marvell* case involved a significant competitor of Defendants in the storage business and was widely reported on, Defendants' executives knew of the case, knew of the Patents, and knew that CMU owned them.

171. Defendants had knowledge of both of the Patents and that they were infringing them.

172. CMU further put Defendants on notice of the Patents and their infringement by letter dated September 1, 2017.

COUNT I—INFRINGEMENT OF THE '839 PATENT

173. The allegations set forth in Paragraphs 1-172 are incorporated herein by reference.

174. Defendants are now and/or have been directly and/or indirectly infringing method claims of the '839 Patent, as proscribed by 35 U.S.C. § 271, *et seq.*, by, without permission or authority from CMU or any license of the Patents, using within the United States, including this district, data detectors (including Viterbi-like detectors), including, specifically, the Exemplary Accused Products (collectively "Data Detectors") such that when the Data Detectors are operated, they perform and directly infringe methods claimed in the '839 Patent, including claim 4.

175. Defendants have directly infringed and continue to directly infringe method claims of the ’839 Patent, including claim 4, by using the Data Detectors in the United States without authority.

176. As a direct and proximate result of Defendants’ infringement of the ’839 Patent, CMU has been and continues to be damaged.

177. Defendants have indirectly infringed and continue to indirectly infringe method claims of the ’839 Patent, including claim 4, by actively inducing their HDD manufacturer customers to use the Data Detectors in the United States, without authority, in a manner that, when the Data Detectors are operated, they perform and directly infringe methods claimed in the ’839 Patent, including claim 4. Among other things, Defendants provide the Data Detectors to their HDD manufacturer customers with instructions on how to use them to infringe at least claim 4 of the ’839 Patent. Furthermore, Defendants were aware of the ’839 Patent or were willfully blind to it. Defendants knew or should have known that their actions would induce their HDD manufacturer customers to directly infringe the methods claimed in the ’839 Patent, including claim 4, and intended that their actions would induce direct infringement by such HDD manufacturer customers.

178. Defendants have also indirectly infringed and continue to indirectly infringe method claims of the ’839 Patent, including claim 4, by contributing to the direct infringement by, for example, HDD manufacturer customers and end-users of the method claims of the ’839 Patent, including claim 4. The components of the read channel in Defendants’ Data Detectors that apply the selected branch metric functions to multiple time variant samples from the readback signal in order to compute branch metric values for branches of a trellis of a detector are a material part of the invention. Defendants offer to sell and sell in the United States the Data Detectors, knowing that the components of the read channel in Defendants’ Data Detectors that apply the selected branch metric functions to multiple time variant samples from the readback signal in order to compute branch metric values for branches of a trellis of a detector are especially made or especially adapted for use in the infringement of the ’839 Patent and are not a staple article or commodity of commerce suitable for any substantial non-infringing use.

179. As a direct and proximate result of Defendants' indirect infringement of the '839 Patent, CMU has been and continues to be damaged.

180. By engaging in the conduct described herein, Defendants have injured CMU and are thus liable for infringement of the '839 Patent, pursuant to 35 U.S.C. § 271.

181. Defendants have committed these acts of infringement without license or authorization.

182. Defendants have committed these acts of infringement with knowledge of the '839 Patent and thus have acted recklessly and willfully with regard to CMU's rights in the '839 Patent.

183. As a result of Defendants' willful infringement of the '839 Patent, the University has suffered monetary damages and is entitled to a monetary judgment in an amount adequate to compensate for Defendants' past infringement, together with enhanced damages, attorneys' fees, interest, and costs.

COUNT II—INFRINGEMENT OF THE '180 PATENT

184. The allegations set forth in Paragraphs 1-183 are incorporated herein by reference.

185. Defendants are now and/or have been directly and/or indirectly infringing method claims of the '180 Patent, as proscribed by 35 U.S.C. § 271, *et seq.*, by, without permission or authority from CMU or any licensee of the Patents, using within the United States, including this district, the Data Detectors such that when the Data Detectors are operated, they perform and directly infringe methods claimed in the '180 Patent, including claim 2.

186. Defendants have directly infringed and continue to directly infringe method claims of the '180 Patent, including claim 2, by using the Data Detectors in the United States without authority.

187. As a direct and proximate result of Defendants' infringement of the '180 Patent, CMU has been and continues to be damaged.

188. Defendants have indirectly infringed and continue to indirectly infringe method claims of the '180 Patent, including claim 2, by actively inducing their HDD manufacturer customers to use the Data Detectors in the United States, without authority, in a manner that, when the Data Detectors are operated, they perform and directly infringe methods claimed in the '180

Patent, including claim 2. Among other things, Defendants provide the Data Detectors to their HDD manufacturer customers with instructions on how to use the Products to infringe claim 2 of the ’180 Patent. Furthermore, Defendants were aware of the ’180 Patent or were willfully blind to it. Defendants knew or should have known that their actions would induce their HDD manufacturer customers to directly infringe the methods claimed in the ’180 Patent, including claim 2, and intended that their actions would induce direct infringement by such HDD manufacturer customers.

189. Defendants have also indirectly infringed and continue to indirectly infringe method claims of the ’180 Patent, including claim 2, by contributing to the direct infringement by HDD manufacturer customers and end-users of the method claims of the ’180 Patent, including claim 2. The components of the read channel in Defendants’ Data Detectors that apply the selected branch metric functions to multiple time variant samples from the readback signal in order to compute branch metric values for branches of a trellis of a detector are a material part of the invention. Defendants offer to sell and sell in the United States the Data Detectors, knowing that the components of the read channel in Defendants’ Data Detectors that apply the selected branch metric functions to multiple time variant samples from the readback signal in order to compute branch metric values for branches of a trellis of a detector are especially made or especially adapted for use in the infringement of the ’180 Patent and are not a staple article or commodity of commerce suitable for any substantial non-infringing use.

190. As a direct and proximate result of Defendants’ indirect infringement of the ’180 Patent, CMU has been and continues to be damaged.

191. By engaging in the conduct described herein, Defendants have injured CMU and are thus liable for infringement of the ’180 Patent, pursuant to 35 U.S.C. § 271.

192. Defendants have committed these acts of infringement without license or authorization.

193. Defendants have committed these acts of infringement with knowledge of the ’180 Patent and thus have acted recklessly and willfully with regard to CMU’s rights in the ’180 Patent.

194. As a result of Defendants’ willful infringement of the ’180 Patent, the University has suffered monetary damages and is entitled to a monetary judgment in an amount adequate to

compensate for Defendants' past infringement, together with enhanced damages, attorneys' fees, interest, and costs.

PRAYER FOR RELIEF

WHEREFORE, the University respectfully requests that this Court hereby enter judgment against Defendants and provide relief as follows:

A. A judgment that Defendants have infringed the Patents;

B. A judgment that Defendants' infringement of the Patents has been willful;

C. An award of damages sufficient to compensate CMU for Defendants' infringement of the Patents, together with pre-judgment interest and costs;

D. An award of all other damages permitted by 35 U.S.C. § 284, including increased damages up to three times the amount of compensatory damages found;

E. A declaration that this is an exceptional case and an award to CMU of its costs and reasonable attorneys' fees incurred in this action as provided by 35 U.S.C. § 285; and

F. Such other relief that this Court deems just and proper.

JURY DEMAND

Pursuant to Federal Rule of Civil Procedure 38(b), CMU hereby demands a trial by jury on all issues triable of right by a jury.

Dated: July 27, 2018

Respectfully submitted,

/s/ *Ranjini Acharya*

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