IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF TEXAS
WACO DIVISION

ZENTIAN LTD., Plaintiff, v. AMAZON.COM, INC. Defendant.	C.A. No. 6:22-cv-00123 **JURY TRIAL DEMANDED**

COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff Zentian Ltd. ("Zentian") demands a trial by jury on all issues so triable and, for its complaint against Defendant Amazon.com, Inc. alleges as follows:

INTRODUCTION

1. Amazon introduced "Alexa" in November 2014.

2. Alexa allows users of Amazon devices, including Amazon Echo smart speakers among others, to engage Amazon's virtual assistant by using only their voice and without physically handling their device. Users activate their device by using a wake word—"Alexa," or alternatively, "Amazon," "Computer," or "Echo".[1] The device then recognizes sounds uttered by the user and converts those acoustic waveforms into information that can be mapped into actions by the digital assistant software, such as searching the internet for real time information, playing a song, making to-do lists, setting alarms, streaming podcasts or audiobooks, purchasing groceries

[1] It is reported that Amazon developers chose the name "Alexa" because it has a hard consonant, which helps speech recognition devices recognize the name with a higher degree of precision. *See* Julie Bort, *Amazon Engineers Had One Good Reason and One Geeky Reason for Choosing the Name Alexa*, Business Insider (July 12, 2016), https://businessinsider.com/why-amazon-called-it-alexa-2016-7.

from Amazon's Whole Foods, and/or any number of other tasks. This process is known as automatic speech recognition or simply speech recognition.

3. Amazon's implementation of speech recognition that enables users to wake "Alexa" and ask "Alexa" questions hands free was invented and patented by Zentian.

4. Zentian is a technology innovator specializing hardware designs for speech recognition circuits and methods. Zentian was founded in 2000 by Mark Catchpole using funds from the U.K. government's "Smart Award" program—a program that provides funding for innovative projects with the potential for significant growth.

5. In the early 2000s, conventional speech recognition systems were ill-equipped to perform a feature like "Alexa" in a fast and power-efficient manner, let alone facilitate the back-and-forth conversational interactions that Amazon users have with Alexa today. In large part, this shortcoming existed because systems in the art focused on improving algorithms and the models used by speech recognition systems to achieve higher word recognition accuracy and other goals. Such implementation focused on incremental improvements in software that ran on power and memory intensive computers or servers. Another contributing factor was the fact that devices like Amazon's Echo smart speakers are typically used in noisier environments, requiring a more complex model and more intensive computation to obtain adequate results from the speech recognition system.

6. Zentian, however, focused on speech recognition hardware, including specialized chip designs to enable speech recognition in cost, space, and power constrained environments like mobile electronic devices. Zentian's vision was to study speech recognition systems and to design silicon chips that would accelerate the speech recognition process by off-loading all or part of that processing from software running on a CPU to a bespoke silicon system. This approach differed

from that of leading speech recognition companies that were focused on incrementally improving software implementations of speech recognition. Zentian focused on how to design better digital electric circuits (*e.g.*, better hardware).

7. Critically, speech recognition systems can be divided into several discrete processes. First, an audio front-end generates processed speech parameters (referred to as feature or spectral vectors) that describe the characteristics of an audio signal. Second, a calculating means or circuit compares the similarity between feature vectors and a model of predetermined acoustic states. This stage is often referred to as "distance calculations" because the output is a probability of how similar (or different) a feature vector is from a stored acoustic state. And third, a search process attempts to find the most likely set of words spoken from a given vocabulary based on the distance calculations.

8. Among the prototypes Zentian developed was a hardware accelerator for the acoustic stage (audio front end and distance calculation) of the speech recognition process that worked alongside a software implementation of the search stage running on a conventional processor. The accelerator demonstrated a two-times speedup of the speech recognition software compared to a conventional speech recognition software-only solution. Moreover, the prototype proved that segregating the speech recognition process onto bespoke hardware components could help solve the shortcomings of conventional systems and enable more advanced features like Amazon's "Alexa."

9. In the 2000s, Zentian had a number of conversations about its acoustic accelerator with leading speech recognition companies, such as Nuance Communications Inc. and IBM, as well as cellular carriers, such as Hutchison 3G UK Limited. But each speech recognition company expressed a desire to focus on software-only solutions and an unwillingness to divert resources to

"longer-term" ideas for speech recognition systems. At the 2006 GSM World Congress in Barcelona, a senior executive at Qualcomm, one of the preeminent suppliers of silicon chips for mobile electronic devices, tellingly stated that speech recognition was "not even in my top ten wish list." Put simply, the industry was not focused on hardware-centric solutions for speech recogntion. Zentian was.

10. Zentian's work resulted in several U.S. patents, including U.S. Patent Numbers 7,587,319; 7,979,277; 10,971,140; 10,062,377; and 10,839,789 (collectively, the "Asserted Patents"). These patents have now been widely cited on patents filed by a host of companies that provide speech recognition technology or end-user products that utilize speech recognition technology, including Samsung, Google, Nuance Communications Inc., Microsoft, and Voci Technologies Inc. And most notably, Amazon itself has cited and discussed Zentian's work when applying for its own patents with the United States Patent and Trademark Office.

11. Today, speech recognition capabilities are in all kinds of products from phones to cars to smart speakers. Amazon's implementation of speech recognition technology in its products "on-device" involves a combination of general-purpose processors combined with hardware accelerators—the very speech recognition circuit and/or system Zentian invented and claimed in the Asserted Patents.

12. On information and belief, Amazon has generated substantial sales of devices incorporating Alexa and other on-device speech recognition features. On average, end users make multiple requests for Alexa per day through the "Alexa" wake word function. In turn, Alexa and the fluidity of the speech recognition processes that are behind it (facilitated by the hardware architecture on which it runs) have become a material driver of user demand for Amazon products.

13. But more than the user's experience with an individual device, Amazon's infringing speech recognition technology funnels device users to shop and purchase other non-infringing products from Amazon's online marketplaces. For example, Amazon Whole Foods actively markets the use of Alexa to facilitate online grocery shopping at Whole Foods (a practice that has grown substantially during the pandemic). According to Amazon, "Alexa makes it even easier to shop for fresh and organic groceries from Whole Foods Market—just tell Alexa what you need."[2]

14. Amazon has infringed and is still infringing, directly and indirectly, one or more claims of the Asserted Patents by making, using, selling, and offering to sell in the United States, including in this District, and importing into the United States, products that implement the Asserted Patents' speech recognition technology.

15. Among other things, Amazon's infringing activity includes the design and development of the speech recognition circuits and systems that are incorporated into its products at Amazon Lab126, a wholly owned subsidiary of Amazon that is responsible for the computer hardware in many of Amazon's products.

16. Examples of potentially infringing products include Amazon's Echo, Echo Dot, Echo Studio, Echo Show, Echo Auto, Echo Buds, Echo Frames, Fire TV Cube, Fire TV Stick, and certain Fire Tablets, in their various models and iterations (the "Accused Products").[3]

17. This list of Accused Products is non-limiting and based on information currently available to Zentian. Zentian reserves the right to modify the list of Accused Products as discovery progresses, including as new products are released during the pendency of this case.

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[2] *See* Introducing Alexa and Prime Now for Whole Foods Market delivery (Sept. 11, 2018), https://www.amazon.com/primeinsider/tips/prime-now-alexa-whole-foods.html.

[3] *See, e.g.* Amazon Echo & Alexa Devices, https://www.amazon.com/gp/browse.html?node=9818047011&ref_=nav_em__ods_ha_echo_cp_0_2_4_15.

THE PARTIES

18. Zentian is a private corporation incorporated and registered in the United Kingdom, with its registered address at 27 Queens Close, St. Ives, Cambridgeshire, England, PE27 5QD.

19. Zentian is the owner of all rights, title, and interest in the Asserted Patents.

20. On information and belief, Defendant Amazon.com, Inc. is a Delaware corporation with its principal place of business at 410 Terry Avenue North, Seattle, Washington 98109.

JURISDICTION AND VENUE

21. This is an action for patent infringement arising under the patent laws of the United States of America, Title 35 of the United States Code.

22. This Court has subject matter jurisdiction over this action pursuant to 28 U.S.C. §§ 1331 and 1338(a) and 35 U.S.C. § 271 *et seq*.

23. This Court's exercise of personal jurisdiction over Amazon complies with both the Texas long-arm statue and the Due Process Clause of the Fourteenth Amendment. Defendant Amazon.com, Inc., individually and by and through its subsidiaries, such as Amazon Lab126, Inc., has multiple places of business in this District and continuously and systematically conducts business in this District, including by distributing and selling infringing products to residents of this District and by soliciting business from residents in this District.

24. Amazon has purposely directed its activities toward Texas and has availed itself of the privileges of conducting activities in the state. Amazon maintains offices in Austin, Texas and markets, offers, manufactures, designs and distributes the Accused Products throughout the United States, including in the state of Texas and in this judicial District.

25. Venue is proper under 28 U.S.C. §§ 1391(b) and (c) and 28 U.S.C. § 1400(b).

26. Amazon has committed acts of infringement in this District and has a regular and established place of business here, including offices in Austin, Texas at 11815 Alterra Pkwy,

11601 Alterra Pkwy, and 11501 Alterra Pkwy, where Amazon's Austin Tech Hub is based.[4]

27. Amazon also has a massive presence in Waco, Texas. Amazon has recently built and begun to operate a $200 million fulfilment center in Waco. The fulfillment center created more than 1,000 jobs, making Amazon the fifth largest employer in Waco. And on information and belief, Amazon has or will receive more than $9.5 million in tax breaks from the City of Waco.[5]

28. Upon information and belief, Amazon also employs individuals in this District who contribute to Amazon's design and sale of infringing products. At Amazon's Austin Tech Hub, Amazon maintains teams of employees that focus on, among other things, Amazon devices, including Accused Products like the Amazon Echo Auto.[6] For example, Amazon employs over 400 individuals in the Austin and Waco metropolitan area with a job title that includes "Amazon Alexa" and/or SoC engineer, including more than 100 employees who identify their employer as "Amazon Lab126."[7] Upon further information and belief, Amazon maintains a workforce of more than 11,000 employees in the Austin area (and more than 22,000 in Texas), making it one of the

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[4] *See, e.g.* John Egan, *Amazon Surprises Austin with Delivery of 600 New Jobs to Domain Campus* (Sep. 20, 2019), https://austin.culturemap.com/news/city-life/09-20-19-amazon-600-jobs-in-north-austin-domain-campus-hiring/.

[5] *See, e.g. Amazon Announces First Fulfillment Center in Waco, TX*, BusinessWire (Oct. 23, 2020), https://www.businesswire.com/news/home/20201023005385/en/Amazon-Announces-First-Fulfillment-Center-in-Waco-TX; *see also* Video: Take a look at the Waco Amazon fulfillment center as it nears completion, https://www.kcentv.com/article/news/local/waco-amazon-fulfillment-center-nears-completion/500-7df3f554-0e78-4219-b937-6b4b478eaf6f.

[6] *See Amazon Expands Austin Tech Hub and Announces Plans to Create 800 New Tech Jobs*, BusinessWire (March 28, 2019), www.businesswire.com/news/home/20190328005489/en/.

[7] *See, e.g.* Parth Acharaya ("Product @ Amazon Alexa Smart Home"), LinkedIn profile available online at https://www.linkedin.com/in/parthacharya/; Jigar Vora ("Senior Software Engineer at Amazon Alexa"), LinkedIn profile available online at https://www.linkedin.com/in/jigarv/; Gijo Arickan ("Embedded Software Engineer at Amazon Lab126"), LinkedIn profile available online at https://www.linkedin.com/in/gijo-arickan-38585738/; C. Bala Kumar ("Senior Manager, Software Development at Amazon Lab126"), LinkedIn profile available online at https://www.linkedin.com/in/c-bala-kumar/.

top private-sector employers in the region.[8]

29. Amazon has also sought to recruit individuals for employment within this District through its website, LinkedIn, and other websites. This includes recent postings seeking to fill hundreds of full-time positions for Hardware Development Engineers and/or Artificial Intelligence and Machine Learning Annotation Analyst on the Alexa Team.[9]

30. On information and belief, Amazon has invested over $7 billion in this District and in Texas more generally, from building customer fulfillment facilities, cloud infrastructure, and a 253-megawatt (MW) wind farm, to compensation to its teams. Amazon estimates that these direct investments contributed more than $5 billion to Texas' economy (2011-2017) and generated an additional 30,000 indirect jobs on top of the company's direct hires.[10] According to Amazon,

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[8] *Id.*; *See also, e.g.* Kathryn Hardison, *Could Amazon Become Austin's Largest Private Employer Soon? At The Current Rate, Yes* (Aug. 12, 2021) https://www.kxan.com/news/business/could-amazon-become-austins-largest-employer-soon-at-the-current-rate-yes/.

[9] *See, e.g.,* Amazon LinkedIn Job postings, https://www.linkedin.com/jobs/search/–?f_C=1586&geoId=102748797&keywords=Alexa%20firmware&location=Texas%2C%20United%20States ("Hardware Development Engineer" for Amazon Lab126); https://www.linkedin.com/jobs/search/?currentJobId=2844211276&f_C=1586&geoId=102748797&keywords=alexa%20lab126&location=Texas%2C%20United%20States ("Senior Embedded Software Development Engineer"); https://www.linkedin.com/jobs/search/?currentJobId=2798020304&f_C=1586&geoId=104472865&keywords=alexa%20speech&location=Austin%2C%20Texas%2C%20United%20States ("Senior Technical Product Management, Alexa Skills Kit"); and https://www.linkedin.com/jobs/search/?currentJobId=2847113070&distance=5&f_C=1586&geoId=103659815&keywords=alexa%20speech%20recognition&location=Waco%2C%20Texas%2C%20United%20States ("Senior Applied Scientist, Alexa Speech, Alexa SpeakerID"); *See also* Amazon's Amazon Jobs website, https://www.amazon.jobs/en/search?base_query=&loc_query=austin+texas&latitude=30.26759&longitude=-97.74299&loc_group_id=&invalid_location=false&country=USA&city=Austin&region=Texas&county=Travis (listing more than 500 jobs in Austin, Texas, including more than 140 positions on the Amazon Devices Team, the team behind the Amazon Echo line of products and Alexa, the voice service that powers Amazon's Echo devices).

[10] *See Amazon Expands Austin Tech Hub and Announces Plans to Create 800 New Tech Jobs*, BusinessWire (Mar. 28, 2019), https://www.businesswire.com/news/home/20190328005489/en/.

"[w]ith a strong pool of technical talent in Austin and a dynamic quality of life, we are excited to continue to expand and create more opportunity in this vibrant city."[11]

31. Upon information and belief, Amazon has maintained a physical presence in this District for years. Amazon owns a 3.8 million square foot location in Pflugerville, Texas at 2000 E Pecan Street, where it maintains a fulfillment center; Amazon also has a fulfillment center in San Marcos, Texas at 1401 E. McCarthy Lane. Upon information and belief, Amazon also has many additional facilities in this District, including but not limited to delivery stations in Austin, Buda, and Round Rock, and a sortation center in Kyle, Texas.[12]

32. Importantly, on information and belief, key witnesses with information about the development, implementation, use, and sale of the Accused Products reside and work within the District. For example, on information and belief, Bala Kumar, who is head of Amazon's Echo team and the most senior individual in Amazon's Austin office, resides and works in Austin, Texas. Mr. Kumar identifies himself as an engineer with "experience in building, leading, and mentoring global teams" that deliver "high performance systems," including "KNUPATH Neural networks stack"[13] Notably, Knupath was a start-up company founded by former NASA chief Dan Goldin that focused on the development of neural networks for speech recognition in the presence of noise (in both hardware and software).[14]

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[11] *Id.* (quoting Terry Leeper, General Manager of Amazon's Austin Tech Hub).

[12] *See* Trent Thompson, *Amazon To Open New Austin Delivery Station in 2022* (Aug. 18, 2021), https://communityimpact.com/austin/central-austin/economy/2021/08/17/amazon-to-open-new-austin-delivery-station-in-2022/.

[13] *See* C Bala Kumar, Senior Manager, Software Development (we are hiring!) at Amazon Lab126), LinkedIn profile available online at https://www.linkedin.com/in/c-bala-kumar/

[14] *See A former NASA chief just launched this AI startup to turbocharge neural computing*, Computr World (June 6, 2016), https://www.computerworld.com/article/3079410/a-former-nasa-chief-just-launched-this-ai-startup-to-turbocharge-neural-computing.html.

33. Moreover, as described below, many of the Accused Products implement Amazon's infringing speech recognition technology on Intel chips. Intel is a designer and manufacturer of various processors and System on Chips. Intel is headquartered in Austin, Texas, where it employs close to 2000 people.[15] In pertinent part, this means that on information and belief, components central to Amazon's acts of infringement were designed and developed in this District, by individuals who reside and work here.

34. On information and belief, critical documents regarding the Accused Products are also located in this District given the presence of Intel, Mr. Kumar and other Amazon employees that live in the District and work on Amazon's infringing speech recognition technology.

ZENTIAN BREAKS NEW GROUND

35. Mark Catchpole, Zentian's founder and one of the named inventors on the Asserted Patents, holds a B.Sc. degree in Physics from the University of Edinburgh and a M.Sc. degree in Microelectronics Systems Design from Brunel University in London. After initial stints teaching physics, Catchpole joined Phoenix VLSI and later PixelFusion as an electronics engineer working on Application Specific Integrated Circuit (ASIC) and Field Programmable Gate Array (FPGA) designs. ASICs and FPGAs are two forms of integrated circuits or chips that allow for customization of hardware after manufacturing.

36. Most of the work by Zentian was—and still is—unpaid, as funds proved difficult to raise during the early 2000s recession following the dot-com crash. Engineers worked in exchange for share options in the company, investing their own sweat equity into the potential of

[15] *See* Innovating and Investing in Texas, https://www.intel.com/content/www/us/en/corporate-responsibility/intel-in-texas.html.

a hardware system-on-chip solution for speech recognition. During this time, Zentian was able to build a partial prototype on a programmable hardware emulation platform.

37. Guy Larri joined the Zentian team in 2004 as a technical contributor. Larri holds a B.Sc. degree in Mathematics and Computer Science, as well as an engineering degree in Electrical Engineering from the University of Sydney. Larri has worked as a VLSI (very large-scale integration) chip design engineer, designing audio processor chips, cache, memory controllers, and other microprocessors.

38. After Larri joined, Zentian's efforts shifted to the creation of a hardware accelerator for the acoustic stage of the speech recognition process that would work alongside a separate software implementation of the search stage (presumably running on a conventional mobile processor). Once the design specifications were created, the Zentian acoustic accelerator was loaded onto a programmable gate array (a type of integrated circuit designed to be customized after manufacturing) and paired with the Sphinx open-source speech recognition software. The Zentian accelerator demonstrated a two-times speedup of the Sphinx software.

39. The implications of the Zentian team's discovery were vast and addressed a number of shortcomings of speech recognition systems in the art that had stymied the technology's commercial development. Speeding up the speech recognition process and reducing the overall power consumption would allow for the speech recognition system to run on a cheaper and/or lower-power processor and memory system. The Zentian accelerator would allow for the overall time the system might take to respond to spoken queries to be significantly reduced to a level more in-line with human conversations. Finally, Zentian's accelerator approach would allow for the use of larger and more sophisticated acoustic models without increasing response time, facilitating better recognition accuracy and a larger recognizable vocabulary.

40. Buoyed by their proof of concept, Catchpole and Larri attempted to market Zentian's acoustic accelerator hardware. They spoke with representatives of leading speech recognition companies, such as Nuance, IBM, Sensory, Inc., and Samsung, as well as cellular carriers, such as Hutchison 3G UK Limited. Catchpole and Larri also attended the 2006 GSM World Congress in Barcelona, where they discussed their novel speech recognition SoC designs with an executive from Qualcomm. Unfortunately, the industry at the time remained focused on software solutions for smaller problems, such as voice-controlled phone dialing.

ZENTIAN'S PATENTS

41. As a result of its work in the speech recognition field, Zentian has a patent portfolio that covers a range of inventions that improve the performance and efficiency of speech recognition on-device systems, including inventions in the area of parallel processing and circuit configurations. Five of Zentian's patents, originating from two separate patent families, are at issue in this case.

42. U.S. Patent No. 7,979,277 (the "'277 patent") is entitled "Speech Recognition Circuit and Method" and issued on July 12, 2011. A true and correct copy of the '277 patent is attached as **Exhibit A** to this Complaint.

43. Under 35 U.S.C. § 154(b), the '277 patent is entitled to 1,043 days of Patent Term Adjustment, extending its expiry date until July 2028.

44. Zentian is the owner of all rights, title, and interest in and to the '277 patent, with the full and exclusive right to file suit and enforce the '277 patent, including the right to recover damages for past infringement.

45. The '277 patent is valid and enforceable under U.S. patent laws.

46. The '277 patent claims are directed to a patent-eligible, non-abstract idea. They address, among other things, a specific improvement to the way in which conventional software-

based speech recognition systems operated on electronic devices. The '277 patent claims include an architecture for a speech recognition circuit in which data is "pipelined" between different hardware componentry. The claims specify materials (including types of processors, accelerator interfaces, etc.), structures, and configurations of the claimed speech recognition circuit designed to enhance power consumption and efficiency of the system and allow for real-time processing of more complex and robust language models.

47. U.S. Patent No. 7,587,319 (the "'319 patent") is entitled "Speech Recognition Circuit Using Parallel Processors" and issued on September 8, 2009. A true and correct copy of the '319 patent is attached as **Exhibit B** to this Complaint.

48. Under 35 U.S.C. § 154(b), the '319 patent is entitled to 1,137 days of Patent Term Adjustment, extending its expiry date until March 2026.

49. Zentian is the owner of all rights, title, and interest in and to the '319 patent, with the full and exclusive right to file suit and enforce the '319 patent, including the right to recover damages for past infringement.

50. The '319 patent is valid and enforceable under U.S. patent laws.

51. The '319 patent claims are directed to a patent-eligible, non-abstract idea. They address, among other things, a specific improvement to the way in which conventional software-based speech recognition systems operated on electronic devices. The '319 patent claims include novel uses of a plurality of lexical tree processors connected in parallel to distribute the task of performing word recognition across processors.[16] This architecture provides for improved and faster processing, solving one of the problems of speech recognition known in the art—the computationally intensive search process that attempts to find the most likely set of words from a

[16] A "lexical tree" is a data structure that comprises a model of words.

given lexicon. The claims specify materials (including types of processors, accelerator interfaces, etc.), structures, and configurations designed to enhance power consumption and efficiency of the system and allow for real-time processing of more complex and robust speech models.

52. U.S. Patent No. 10,971,140 (the "'140 patent") is entitled "Speech Recognition Circuit Using Parallel Processors" and issued on April 6, 2021. A true and correct copy of the '140 patent is attached as **Exhibit C** to this Complaint.

53. Under 35 U.S.C. § 154(b), the '140 patent is entitled to 0 days of Patent Term Adjustment, and its expiry date is in February 2023.

54. Zentian is the owner of all rights, title, and interest in and to the '140 patent, with the full and exclusive right to file suit and enforce the '140 patent, including the right to recover damages for past infringement.

55. The '140 patent is valid and enforceable under U.S. patent laws.

56. The '140 patent claims are directed to a patent-eligible, non-abstract idea. They address, among other things, a specific improvement to the way in which conventional software-based speech recognition systems operated on electronic devices. The '140 patent claims include a speech recognition circuit that has one or more clusters of processors, each of which comprises a plurality of processors and an acoustic model memory for storing acoustic model data. The disclosed and claimed circuit is further configured to generate an initial score for an audio sample, which is then used to determine whether to continue processing to determine a final score by processing a larger amount of model data than that which was processed to generate the initial score. The claims specify materials (including types of processors, accelerator interfaces, etc.), structures, and configurations of the claimed speech recognition circuit designed to enhance power

consumption and efficiency of the system and allow for real-time processing of more complex and robust language models.

57. U.S. Patent No. 10,062,377 (the "'377 patent") is entitled "Distributed Pipelined Parallel Speech Recognition System" and issued on August 28, 2018. A true and correct copy of the '377 patent is attached as **Exhibit D** to this Complaint.

58. Under 35 U.S.C. § 154(b), the '377 patent is entitled to 0 days of Patent Term Adjustment, and its expiry date is in September 2025.

59. Zentian is the owner of all rights, title, and interest in and to the '377 patent, with the full and exclusive right to file suit and enforce the '377 patent, including the right to recover for damages for past infringement.

60. The '377 patent is valid and enforceable under U.S. patent laws.

61. The '377 patent claims are directed to a patent-eligible, non-abstract idea. They address, among other things, a specific improvement to the way in which conventional software-based speech recognition systems operated on electronic devices. The '377 patent claims include, among other things, a speech recognition system comprising a device programmed to calculate a feature vector from a digital audio stream (wherein the feature vector comprises a plurality of extracted and/or derived quantities from the stream during a defined audio time frame); a second device programmed to calculate distances indicating the similarity between the calculated feature vector and a plurality of acoustic states of an acoustic model; and a third device programmed to identify spoken words in the digital audio stream using Hidden Markov Models and/or Neural Networks. The system also includes a search stage for using the calculated distances to identify words within a lexical tree (the lexical tree comprising a model of words). The claims specify materials (including types of processors, accelerator interfaces, etc.), structures, and configurations

of the claimed speech recognition system designed to reduce power consumption and improve efficiency of the system and to allow for real time processing of more complex and robust language models.

62. U.S. Patent No. 10,839,789 (the "'789 patent") is entitled "Speech Recognition Circuit and Method" and issued on November 17, 2020. A true and correct copy of the '789 patent is attached as **Exhibit E** to this Complaint.

63. Under 35 U.S.C. § 154(b), the '789 patent is entitled to 0 days of Patent Term Adjustment, and its expiry date is in September 2025.

64. Zentian is the owner of all rights, title, and interest in and to the '789 patent, with the full and exclusive right to file suit and enforce the '789 patent, including the right to recover for past infringement.

65. The '789 patent is valid and enforceable under U.S. patent laws.

66. The '789 patent claims are directed to a patent-eligible, non-abstract idea. They address, among other things, a specific improvement to the way in which conventional software-based speech recognition systems operated on electronic devices. The '789 patent claims include an acoustic coprocessor for processing data associated with an audio signal that includes an interface for receiving at least one feature vector, a calculating apparatus for calculating distances indicating a similarity between the feature vector and acoustic state of an acoustic model, and a second interface for sending at least one distance calculated by the calculating apparatus. The claims specify materials (including types of processors, accelerator interfaces, etc.), structures, and configurations of acoustic coprocessors designed to enhance power consumption and efficiency of the system and allow for real time processing of more complex and robust language models.

67. For ease of reference, the '277, '377, and '789 patents are part of the same patent family. The '319 and '140 patents are part of the same patent family.

AMAZON'S UNAUTHORIZED USE OF ZENTIAN'S TECHNOLOGY

68. First introduced in 2014, Alexa uses speech recognition and natural language processing to enable Amazon devices to play music, control smart home accessories, listen to audio books, answer general knowledge inquiries, set clocks and timers, obtain news and weather information, purchase groceries and other products at Whole Foods, make grocery lists, and even get traffic reports and translations.[17] As stated by Amazon, "Alexa makes your life easier, more meaningful, and more fun by letting your voice control your world."[18]

69. Alexa is central in shaping the user experience of many Amazon products, including Accused Products like Amazon's Echo devices. But more than the user's experience with an individual device, Amazon's infringing speech recognition technology funnels device users to shop and purchase other non-infringing products from Amazon's online marketplaces. This is referred to as "voice commerce" or "voice shopping".[19]

70. For example, Amazon's Whole Foods actively markets the use of Alexa to facilitate online shopping at Whole Foods, a practice that has grown substantially during the pandemic. According to Amazon, "Alexa makes it even easier to shop for fresh and organic groceries from

[17] Total Alexa skills now reportedly exceed 77,000 in the U.S., in part due to usage. *See* Smilijanic Stasha, *Amazon Alexa Statistics, Facts, and Trends*, https://policyadvice.net/insurance/insights/amazon-alexa-statistics/.

[18] *See* Alexa Features, https://www.amazon.com/alexa-skills/b?ie=UTF8&node=13727921011.

[19] In 2018, "[c]ustomers use of Alexa for shopping more than tripled…" *See* Bret Kinsella, *Amazon Says Alexa Voice Shopping Tripled During 2018 Holiday Season*, Voicebot.ai (Dec. 31, 2018), https://voicebot.ai/2018/12/31/amazon-says-alexa-voice-shopping-tripled-during-2018-holiday-season/.

Whole Foods Market—just tell Alexa what you need."[20] Indeed, the very concept behind an always-on smart speaker was for a speaker to remain always-on, listening for and processing voice queries from users, enabling those users to shop without leaving their living room and generating substantial sales of products and services for Amazon.

71. On information and belief, Alexa fulfills billions of user requests each month, many of them to purchase products (some provided by Amazon and others provided by third-parties) through Amazon's online market place. Alexa is, in turn, a core feature built into almost every smart device Amazon sells. And Amazon sells a lot of smart devices. Its sales of Echo speakers, for example, account for an estimated 53% of the U.S. smart speaker market in 2020.[21]

72. On information and belief, on-device voice processing, such as through the Alexa wake word technology, is fundamental to selling Amazon's Accused Products because it allays user privacy concerns and allegedly speeds up performance and reliability of the devices.[22] By keeping the "always on" wake word function on-device, users don't have to worry about Amazon "listening in" on their private conversations. To the extent, Amazon servers receive any of the user's words or content, it is not until the wake word is spoken and the user is directing their speech at the Accused Product.

73. Amazon's infringement of on-device speech recognition features includes, among other things: (1) Wake phrase detection for "Alexa" and/or other wake words; (2) Dictation of text messages and notes with integrated applications; and (3) On device speech recognition for Alexa

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[20] *See* Introducing Alexa and Prime Now for Whole Foods Market delivery, https://www.amazon.com/primeinsider/tips/prime-now-alexa-whole-foods.html (Sept. 11, 2018).

[21] *See* Voicebot.ai, *Amazaon Echo and Alexa Stats*, https://voicebot.ai/amazon-echo-alexa-stats/.

[22] As another indication of the importance of voice technology to Amazon's business, Amazon set-aside $200 million to "fuel voice technology innovation … and innovate with Alexa." *See* The Alexa Fund, https://developer.amazon.com/en-US/alexa/alexa-startups/alexa-fund.

user requests. As described in detail below, these features would not be possible without the hardware-first architectures, methods, circuits, configurations, systems, chips and approaches engineered by Zentian in the early 2000s and claimed in the Asserted Patents.

74. Making matters worse, Amazon's infringement is willful. In late 2014, Amazon was in the process of applying for its own U.S. patent. As part of its consideration of an Amazon patent application, the patent examiner cited Zentian's '277 patent as a prior art reference—a filing sent to Amazon—in November 2014. Indeed, Zentian's patent is one of two U.S. patent references cited by the examiner during the application. To this day, the '277 patent appears with an asterisk on the face of Amazon's U.S. Patent No. 8,990,076 entitled "Front-end difference coding for distributed speech recognition."

75. The same is true for Amazon's U.S. Patent No. 9,390,708, titled "Low latency and memory efficient keywork spotting," which allegedly discloses means for "spotting keywords in utterance audio data." That patent application's prosecution history identifies Zentian's '277 patent as a U.S. patent reference cited and considered by the U.S. Patent examiner, and was consequently known to Amazon by the date of issuance, July 12, 2016.

COUNT ONE: INFRINGEMENT OF U.S. PATENT NO. 7,979,277

76. Zentian incorporates by reference and realleges the allegations in paragraphs 1-75.

77. The '277 patent is valid and enforceable.

78. The '277 patent names Guy Larri, Mark Catchpole, Damian Kelly Harris-Dowsett, and Timothy Brian Reynolds as inventors.

79. Amazon has directly infringed, continues to infringe, and has induced or contributed to the infringement of the '277 patent by making, using, selling, and offering for sale, in the United States, and importing into the United States, without authority or license, the Accused Products in violation of 35 U.SC. § 271(a).

80. The Accused Products are non-limiting examples that were identified based on publicly available information. Zentian reserves the right to identify additional infringing activities, products, and services, including based on information obtained during discovery.

81. By way of example only, the Accused Products meet all the limitations of at least independent claims 14, 15, and 16 of the '277 patent, either literally or under the doctrine of equivalents. Claim 14 is directed to a speech recognition circuit, claim 15 to a speech recognition method, and claim 16 to a non-transitory storage medium storing processor implementable code for controlling at least one processor to implement a speech recognition method.

82. Claim 14 of the '277 patent recites:

A speech recognition circuit, comprising:

> [1] an audio front end for calculating a feature vector from an audio signal, wherein the feature vector comprises a plurality of extracted and/or derived quantities from said audio signal during a defined audio time frame;
>
> [2] calculating means for calculating a distance indicating the similarity between a feature vector and a predetermined acoustic state of an acoustic model; and
>
> [3] a search stage for using said calculated distances to identify words within a lexical tree, the lexical tree comprising a model of words;
>
> [4] wherein said audio front end, said calculating means, and said search stage are connected to each other to enable pipelined data flow.

83. Regarding the preamble of claim 14, to the extent the preamble is determined to be limiting, the Accused Products contain a speech recognition circuit that allows for device users to speak the words "Alexa" and activate Amazon's personal assistant hands-free. The speech recognition circuit of the Accused Products further allows for dictation of text messages and notes

with integrated applications or skills, as well as on device speech recognition for Alexa user requests.[23]

84. For example, the "Technical Details" on Amazon's website represent that the Echo Auto features "Wake word technology"—a technical term for a speech recognition system that detects a word or phrase, such as "Alexa" or "Echo," used to initiate a voice query to a voice-based digital assistant. Also, the website indicates that Echo Auto is able to perform speech recognition functions even when the device is offline, such as through the "Local Voice Control extension, which ensures that customers get a reliable response from Alexa regardless of connectivity."[24]

85. On information and belief, the speech recognition circuit of the Accused Products works with cloud-based programming, natural language interpretation and other services with hardware-assisted on-device processing, creating a combination of hardware and software features.[25]

86. As to the first limitation of claim 14 of the '277 patent, the Accused Products calculate a feature vector from an audio signal using an audio front end, wherein the feature vector comprises a plurality of extracted and/or derived quantities from said audio signal during a defined audio time frame.

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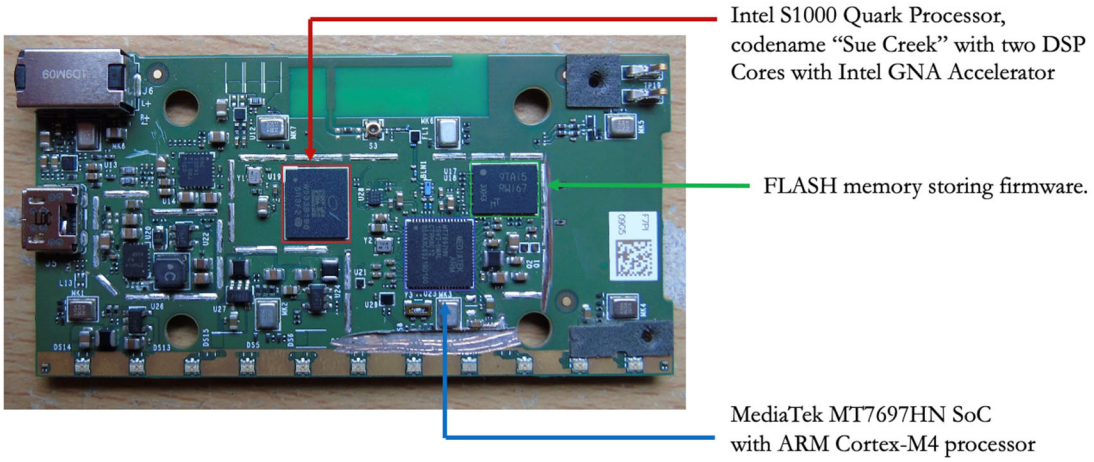
[23] *See* Alexa features, https://www.amazon.com/alexa-skills/b?ie=UTF8&node=13727921011 (describing various functionality as either "Alexa features" that are "something Alexa is able to do from the moment you turn on your Alexa-enabled device, to "Alexa skills," which are functions that require selection from the Skill store and to be enabled on device.)

[24] *See* Adam Foster, *Enabling Offline Access to Alexa in Vehicles with Local Voice Control Extension to Alexa Auto SDK v2.0* (Sept. 10, 2019), https://developer.amazon.com/en-US/blogs/alexa/alexa-auto/2019/09/enabling-offline-access-to-alexa-in-vehicles-with-local-voice-control-extension-to-alexa-auto-sdk-v2-0.

[25] *See Intel Quark S1000 "Sue Creek" Processor to Support On-Chip Speech Recognition*, CNX Software (June 19, 2017), https://www.cnx-software.com/2017/06/19/intel-quark-s1000-sue-creek-processor-to-support-on-chip-speech-recognition (describing speech recognition capabilities of Sue Creek processor in certain Amazon Echo devices).



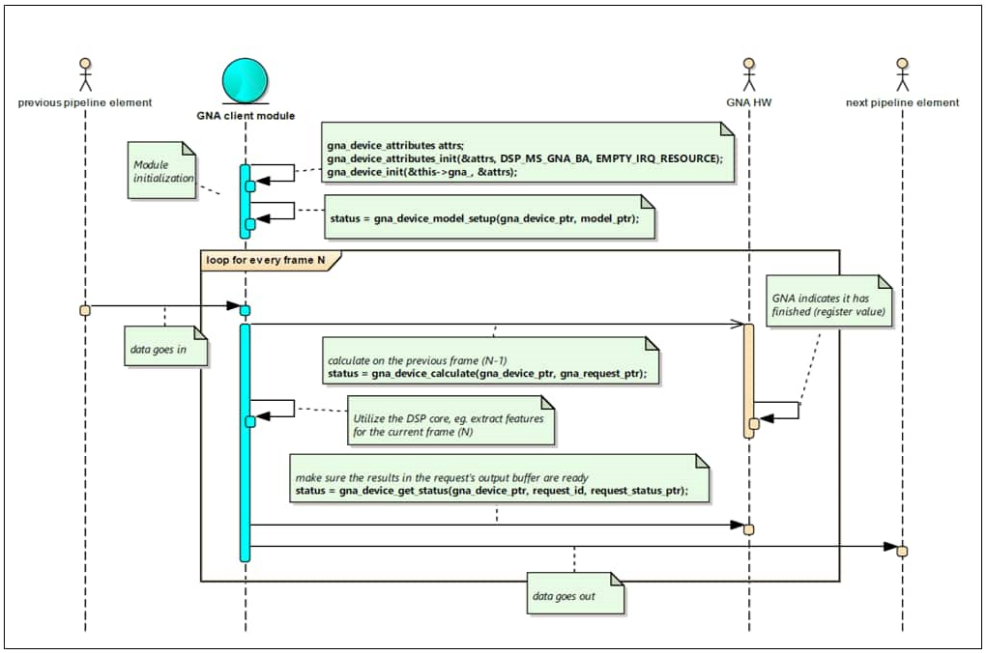
87. By way of non-limiting example, the Echo Auto device includes a Mediatek MT7697 and Intel Dual DSP with Inference Engine, along with an eight-microphone array.[26] Based on an initial product teardown and as photographed above, the Echo Auto contains the Intel S1000 Quark Processor, codename "Sue Creek." The Sue Creek SoC contains two DSP (digital signal processor) cores and an Intel Gaussian and Neural Accelerator (GNA) Inferencing Engine. The Echo Auto also contains Flash memory for storing firmware.

88. According to an Intel programing guide, "[t]he Intel Quark SoC S1000 ASIC is designed for complex far-field signal processing algorithms that use high dimensional microphone arrays to do beamforming, cancel echoes, and reduce noise. A pair of DSPs, a neural network accelerator, internal memory, and a set of I/Os provide the necessary resources for speech processing solutions."[27]

[26] *See* Echo Auto Technical Details: Processor, https://www.amazon.com/dp/B07VTK654B?th=1.

[27] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

89. Moreover, as shown in the below figure from the Intel Quark™ SoC S1000 Firmware Programming Guide, the overall speech recognition system operates on a series of "frames," where processing performs a "loop for every frame N." As the figure below illustrates, one of the DSP cores operates as an audio front-end and is used to calculate feature vectors from the digital audio stream formed from the eight-microphone array that is incorporated into the Echo Auto.[28] Feature vectors comprise a plurality of extracted and/or derived quantities during a defined audio time frame.[29]



90. The Accused Products similarly contain the second limitation of claim 14—a calculating means for calculating a distance indicating the similarity between a feature vector and a predetermined acoustic state of an acoustic model.

[28] *Id.* at Figure 47 (showing the step "[u]tilize the DSP core, e.g. extract features for the current frame (N)).

[29] *Id.*

91. In the case of the Amazon Echo Auto, the calculating means is the Gaussian and Neural Accelerator ("GNA") within the Intel Quark™ SoC S1000. The Intel GNA is a "flexible, low-power, high performance streaming co-processor that offloads neural network inference operations from the DSP and application processor."[30]

92. The Intel GNA is programmed to compute distances between feature vectors and a plurality of acoustic states in an acoustic model.[31] As illustrated in the above figure from Intel Quark™ SoC S1000 Firmware Programming Guide, the GNA receives feature vectors after they have been calculated on the DSP core in accordance with the first claim limitation.[32] The GNA then calculates a distance indicating the similarity or difference between a feature vector and predetermined acoustic state.[33]

93. The Accused Products further contain the third limitation of claim 14 of the '277 patent. Again, by way of example only, the Amazon Echo Auto uses a search stage to identify works within a lexical tree using the calculated distances from the Intel GNA, with the lexical tree comprising a model of words.

94. On information and belief, the search stage is implemented in software running on the second DSP core in the Intel Quark™ S1000 chip. The search stage uses distances (or probabilities) calculated by the GNA to identify multiple pronunciations of words such as "Alexa,"

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[30] *See* G. Stemmer et al., Speech Recognition and Understanding on Hardware-Accelerated DSP, Interspeech (2017).

[31] *See* Michael Deisher, et al., ICASSP GNA poster presentation "Implementation of Efficient, Low Power Deep Neural Networks on Next-Generation Intel Client Platforms" (2017), https://sigport.org/sites/all/modules/pubdlcnt/pubdlcnt.php?fid=1610 (noting that GNA can be programmed to compute a range of mathematical functions which are used to implement Neural Network based acoustic models, such as Affine, Convolutional, etc.).

[32] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

[33] *Id.* at Figure 47 (showing the step "calculate on the previous frame (N-1)")

"Computer," and "Echo." The set of recognized wake word pronunciations is stored in the speech recognition software as a model or words, comprising a lexical tree.[34]

95. As to the fourth limitation of claim 14, the Accused Products pipeline data from the front end to the calculating circuit, and then on to the search stage.

96. As shown in the above figure from the Intel Quark™ SoCS1000 Firmware Programming Guide, data in the Intel GNA flows in a pipelined manner, with the sequencing frames indicating both a "previous pipeline element" and a "next pipeline element" sandwiching the "GNA HW." Based on this depiction, the GNA receives feature vectors after they have been calculated on the DSP core and then performs calculations on the feature vectors that were calculated in the previous frame, the result of which is then delivered to the next pipeline element (*i.e.* the search stage).[35]

97. Amazon actively, knowingly, and intentionally induces infringement of one or more claims of the '277 patent under 35 U.S.C. § 271(b), by actively encouraging others to make, use, sell, and offer to sell in the United States, the Accused Products.

98. For example, Amazon provides directions, instruction manuals, guides, and/or other materials that encourage and facilitate infringing use by others.

99. Amazon has sold and is selling the Accused Products with the knowledge and intent that customers who buy the products will use the products for their infringing use and therefore that customers have been and are directly infringing the '277 patent.

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[34] *See e.g., Intel Quark S1000 "Sue Creek" Processor to Support On-Chip Speech Recognition* CNX Software (June 19, 2017), https://www.cnx-software.com/2017/06/19/intel-quark-s1000-sue-creek-processor-to-support-on-chip-speech-recognition (capabilities diagram describing speech recognition at the edge as being a combination of "3rd party IP/Intel substitute IP" and/or "Available Intel IP," as opposed to "Intel Firmware" and/or "Sue Creek Hardware.")

[35] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, available at: https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

100. Amazon contributes to the infringement of one or more claims of the ’277 patent under 35 U.S.C § 271(c) by offering to sell, selling, or importing into the United States, a component of the Accused Products that constitutes a material part of the inventions, knowing the same to be especially made or especially adapted for use in an infringement of the ’277 patent, and is not a staple article or commodity of commerce suitable for substantial non-infringing use.

101. Amazon was aware of the ’277 patent at least as of November 2014, when the patent examiner cited the ’277 in the prosecution of two Amazon patent applications regarding speech recognition technology.

102. On information and belief, Amazon has been aware of the ’277 patent since its issuance on July 12, 2011.

103. On information and belief, Amazon knew that the Accused Products infringe the ’277 patent, or at a minimum believed there was a high probability that the Accused Products were covered by Zentian’s patents, but willfully blinded itself to Zentian’s patents and the infringing nature of the Accused Products.

104. The foregoing allegations are based on publicly available information and a reasonable investigation of the structure and operation of the Accused Products.

105. Zentian reserves the right to modify this description of alleged infringement, including, for example, on the basis of information about the Accused Products that it obtains during discovery.

106. The infringement details provided for claim 1 of the ’277 patent are exemplary, and Zentian intends to assert additional claims of the ’277 patent beyond claim 14.

107. Amazon's infringement has damaged and continues to damage Zentian in an amount yet to be determined. At the very least, Zentian should receive a reasonable royalty for Amazon's unauthorized use of the claimed inventions set forth in the '277 patent.

108. This is an exceptional case. Zentian is entitled to attorneys' fees and costs under 35 U.S.C § 285 as a result of the infringement of the '277 patent by Amazon.

COUNT TWO: INFRINGEMENT OF U.S. PATENT NO. 7,587,319

109. Zentian incorporates by reference and realleges the allegations in paragraphs 1-108.

110. The '319 patent is valid and enforceable.

111. The '319 patent names Mark Catchpole as its sole inventor.

112. Amazon has directly infringed, continues to infringe, and has induced or contributed to the infringement of the '319 patent by making, using, selling, and offering for sale in the United States, and importing into the United States, without authority or license the Accused Products in violation of 35 U.SC. § 271(a).

113. The Accused Products are non-limiting examples identified based on publicly available information. Zentian reserves the right to identify additional infringing activities, products, and services, including, for example, on the basis of information obtained during discovery.

114. By way of example only, the Accused Products meet all the limitations of at least claim 46 of the '319 patent, either directly or under the doctrine of equivalents, which recites:

A speech recognition circuit, comprising:

[1] an input buffer receiving processed speech parameters:

[2] a plurality of lexical memories containing in combination complete lexical data for word recognition, each lexical memory containing part of said complete lexical data;

> [3] a plurality of processors connected in parallel to said input buffer for processing the speech parameters in parallel, said processors being arranged in groups of processors, each group of processors being connected to a lexical memory:
>
> [4] a control processor controlling each processor to process said speech parameters using partial lexical data read from a respective said lexical memory; and
>
> [5] a results memory storing the results of the processing of the speech parameters from said processors.

115. Regarding the preamble of claim 46, to the extent the preamble is determined to be limiting, the Accused Products contain a speech recognition circuit that allows for device users to speak the words "Alexa," "Amazon," "Computer," or "Echo" and activate Amazon's personal assistant hands-free. The speech recognition circuit of the Accused Products further allows for dictation of text messages and notes with integrated applications or skills, as well as on-device speech recognition for Alexa user requests.[36]

116. For example, the "Technical Details" on Amazon's website represent that the Echo Auto features "Wake word technology"—a technical term for a speech recognition system that detects a word or phrase, such as "Alexa" or "Echo," used to initiate a voice query to a voice-based digital assistant. Also, the website indicates that the Echo Auto is able to perform speech recognition functions even when the device is offline, such as through the "Local Voice Control extension, which ensures that customers get a reliable response from Alexa regardless of connectivity."[37]

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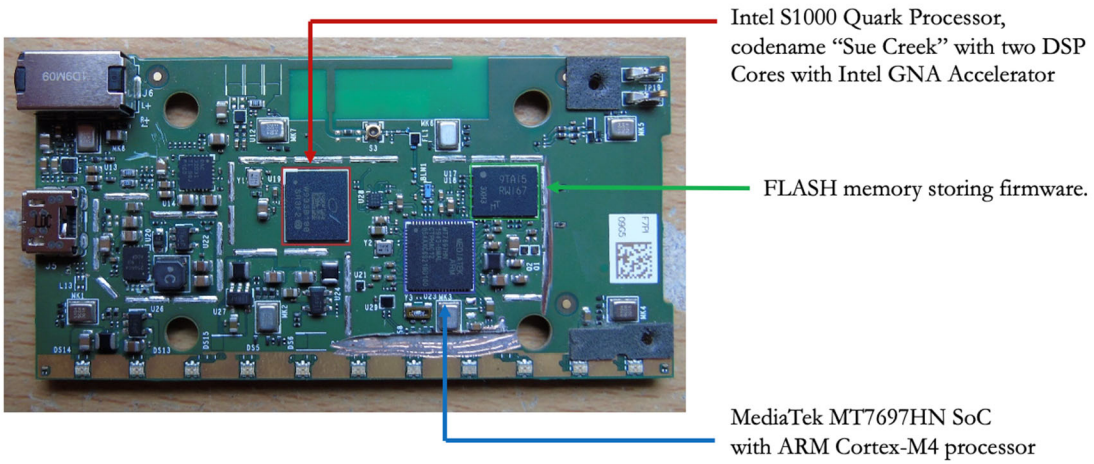
[36] *See* Alexa features, https://www.amazon.com/alexa-skills/b?ie=UTF8&node=13727921011 (describing various functionality as either "Alexa features" that are "something Alexa is able to do from the moment you turn on your Alexa-enabled device, to "Alexa skills," which are functions that require selection from the Skill store and to be enabled on device.)

[37] *See* Adam Foster, *Enabling Offline Access to Alexa in Vehicles with Local Voice Control Extension to Alexa Auto SDK v2.0* (Sept. 10, 2019), https://developer.amazon.com/en-US/blogs/alexa/alexa-auto/2019/09/enabling-offline-access-to-alexa-in-vehicles-with-local-voice-control-extension-to-alexa-auto-sdk-v2-0.

117. On information and belief, the speech recognition circuit of the Accused Products works with cloud-based programming, natural language interpretation and other services with hardware-assisted on-device processing, creating a combination of hardware and software features.[38]

118. As to the first limitation of claim 46 of the '319 patent, the Accused products contain an input buffer receiving processed speech parameters.



119. By way of non-limiting example, the Echo Auto device includes a Mediatek MT7697 and Intel Dual DSP with Inference Engine, along with an eight-microphone array.[39] Based on an initial product teardown and as photographed above, the Echo Auto contains the Intel Quark™ S1000 Quark Processor, codename "Sue Creek." The Sue Creek SoC contains the two DSP cores and an Intel Gaussian and Neural Accelerator (GNA) Inferencing Engine. The Echo

[38] *See Intel Quark S1000 "Sue Creek" Processor to Support On-Chip Speech Recognition,* CNX Software (June 19, 2017), https://www.cnx-software.com/2017/06/19/intel-quark-s1000-sue-creek-processor-to-support-on-chip-speech-recognition (describing speech recognition capabilities of Sue Creek processor in certain Amazon Echo devices).

[39] *See* Echo Auto Technical Details: Processor, https://www.amazon.com/dp/B07VTK654B?th=1.

Auto also contains Flash memory for storing firmware and model data used by the speech recognition process.

120. According to an Intel programing guide, "[t]he Intel Quark SoC S1000 ASIC is designed for complex far-field signal processing algorithms that use high dimensional microphone arrays to do beamforming, cancel echoes, and reduce noise. A pair of DSPs, a neural network accelerator, internal memory, and a set of I/Os provide the necessary resources for speech processing solutions."[40]

121. The block diagram at right shows the Intel GNA with an interface for receiving feature vectors (*i.e.* processed speech parameters) from an audio signal, shown as the end point of arrows from "data arrays" and "network parameter arrays" to "input data buffers" designed to "hold inputs…of each layer."[41]

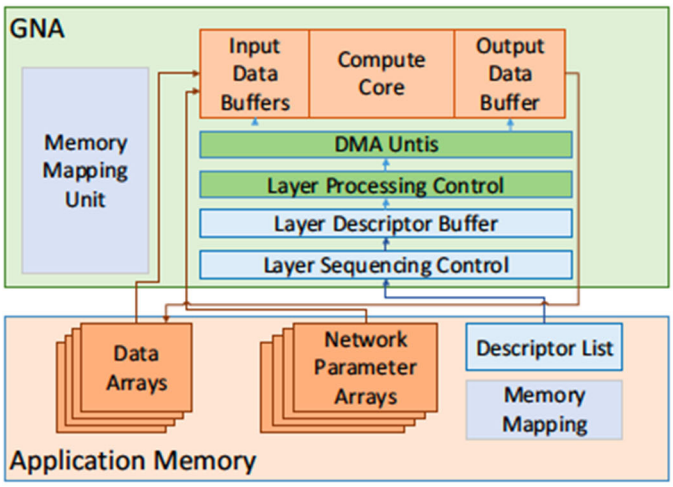


Figure 2: *GNA block diagram and memory organization*

122. As to the second limitation of claim 46 of the '319 patent, the Accused Products contain a plurality of lexical memories containing (in combination) complete lexical data for word recognition. Notably, each Accused Product contains FLASH memory that acts as a non-volatile

[40] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

[41] *See* G. Stemmer et al., Speech Recognition and Understanding on Hardware-Accelerated DSP, Interspeech (2017) at Figure 2.

memory to store data even when the device is turned off or the battery is depleted. For example, the Echo Auto imaged above contains a Micron Technologies MT25Q 256Mb, 1.8V, Multiple I/O Serial Flash Memory.[42]

123. In addition to the FLASH memory, each Accused Product contains a cache memory hierarchy that holds copies of data from the FLASH memory when it is accessed by processing elements, such as two LX6/HiFi3 DSPs in the Sue Creek SoC. On information and belief, each DSP has a private level 1 data cache, depicted as "L1 D$" in the Intel Block Diagram below. Some products may also contain shared caches lower in the cache hierarchy, known as level 2 caches, level 3 caches, or "system caches."

124. On information and belief, the FLASH memory and the caches in the cache hierarchy that lead to the processors are, in combination, the lexical memories containing complete lexical data for word recognition, with each containing some part of that data at any given time during speech processing.

125. As to the third limitation of claim 46 of the '319 patent, the Accused Products include more than one processor for processing speech parameters in parallel arranged in groups (with each group connected to a lexical memory).

[42] *See* Micron, FBGA and Marking Decoder, available at https://www.micron.com/support/tools-and-utilities/fbga?fbga=RW167#pnlFBGA.

126. On information and belief, each of the two DSPs (identified in the block diagram below as LX6/HiFi3) in the Intel S1000 "Sue Creek" processor is a group of processors as the LX6/HiFi3 designation indicates the inclusion of the "HiFi3 Audio/Voice SP" together with the LX6 main DPU[43].

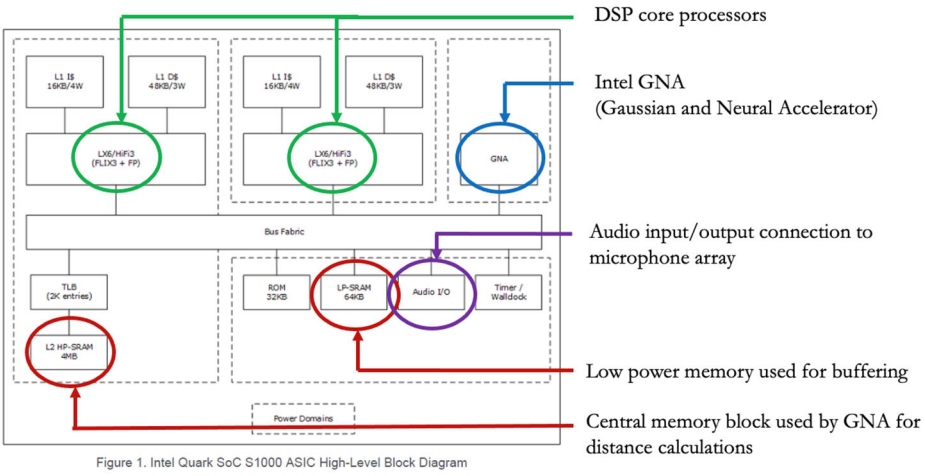


Figure 1. Intel Quark SoC S1000 ASIC High-Level Block Diagram

127. Each instance of LX6/HiFi3 is connected to cache memory (identified in the block diagram as "L1 D$"). On information and belief, these caches along with the Accused Products' FLASH memory are lexical memories because they store some part (or all) of the lexical data for word recognition.

128. The Accused Products also contain the fourth limitation of claim 46 of the '319 patent, which is a control processor that controls each processor that is processing speech parameters using lexical data read from stored lexical memory.

129. On information and belief, the application processor, *i.e.* the Mediatek MT7697, is a control processor, in that it controls the two DSPs and Intel GNA on the Sue Creek SoC that processes speech parameters using lexical data—the lexical data being stored in the FLASH and

[43] *See* Cadence Tensilica Xtensa LX6 Customizable DPU datasheet, https://mirrobo.ru/wp-content/uploads/2016/11/Cadence_Tensillica_Xtensa_LX6_ds.pdf

cache memory structures connected to and shared by the Sue Creek SoC and application processors.[44]

130. Finally, the fifth limitation of claim 46 of the '319 patent is also present in the Accused Products, as each has a results memory storing the results of processed speech parameters.

131. On information and belief, the SRAM depicted in the Intel S1000 block diagram above ("L2 HP-SRAM" and "LP-SRAM") is the working memory of the computation system and would store results of the processed speech parameters from the Intel GNA and DSP processors.

132. Amazon actively, knowingly, and intentionally induces infringement of one or more claims of the '319 patent under 35 U.S.C. § 271(b), by actively encouraging others to make, use, sell, and offer to sell in the United States, the Accused Products.

133. For example, Amazon provides directions, instruction manuals, guides, and/or other materials that encourage and facilitate infringing use by others.

134. Amazon has sold and is selling the Accused Products with the knowledge and intent that customers who buy the products will use the products for their infringing use and therefore that customers have been and are directly infringing the '319 patent.

135. Amazon contributes to the infringement of one or more claims of the '319 patent under 35 U.S.C § 271(c) by offering to sell, selling, or importing into the United States, a component of the Accused Products that constitutes a material part of the inventions, knowing the same to be especially made or especially adapted for use in an infringement of the '319 patent, and is not a staple article or commodity of commerce suitable for substantial non-infringing use.

136. Amazon was aware of the '319 patent at least as of the date of this Complaint.

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[44] *See* MT76x7 Reference Manual (version 1.09) https://usermanual.wiki/Document/MT76x7ReferenceManual.1463370314/view.

137. On information and belief, Amazon has been aware of the '319 patent since its issuance on September 8, 2009.

138. On information and belief, Amazon knew that the Accused Products infringe the '319 patent, or at a minimum believed there was a high probability that the accused products were covered by Zentian's patents, but willfully blinded itself to Zentian's patents and the infringing nature of the Accused Products.

139. The foregoing allegations are based on publicly available information and a reasonable investigation of the structure and operation of the Accused Products.

140. Zentian reserves the right to modify this description of alleged infringement, including, for example, on the basis of information about the Accused Products that it obtains during discovery.

141. The infringement details provided for claim 46 of the '319 patent are exemplary, and Zentian intends to assert additional claims of the '319 patent beyond claim 46.

142. Amazon's infringement has damaged and continues to damage Zentian in an amount yet to be determined. At the very least, Zentian should receive a reasonable royalty for Amazon's unauthorized use of the claimed inventions set forth in the '319 patent.

143. This is an exceptional case. Zentian is entitled to attorneys' fees and costs under 35 U.S.C § 285 as a result of the infringement of the '319 patent by Amazon.

COUNT THREE: INFRINGEMENT OF U.S. PATENT NO. 10,971,140

144. Zentian incorporates by reference and realleges the allegations in paragraphs 1-143.

145. The '140 patent is valid and enforceable.

146. The '140 patent names Mark Catchpole as its sole inventor.

147. Amazon has directly infringed, continues to infringe, and has induced or contributed to the infringement of the '140 patent by making, using, selling, and offering for sale

in the United States, and importing into the United States, without authority or license the Accused Products in violation of 35 U.SC. § 271(a).

148. The Accused Products are non-limiting examples identified based on publicly available information. Zentian reserves the right to identify additional infringing activities, products, and services, including, for example, on the basis of information obtained during discovery.

149. By way of example only, the Accused Products meet all the limitations of at least claim 1 of the '140 patent, either literally or under the doctrine of equivalents, which recites:

A speech recognition circuit, comprising:

> [1] one or more clusters of processors, each of the one or more cluster of processors comprising:
>
> [2] a plurality of processors; and
>
> [3] an acoustic model memory storing acoustic model data, wherein each of the plurality of processors is configured to compute a probability using the acoustic model data in the acoustic model memory, wherein:
>
> [4] the speech recognition circuit is configured to generate an initial score for an audio sample; and
>
> [5] the initial score is used to determine whether to continue processing to determine a final score via processing a larger amount of model data than that was processed to generate the initial score.

150. Regarding the preamble of claim 1, to the extent the preamble is determined to be limiting, the Accused Products contain a speech recognition circuit that allows for device users to speak the words "Alexa," "Amazon," "Computer," or "Echo," and activate Amazon's personal assistant hands-free. The speech recognition circuit of the Accused Products further allows for

dictation of text messages and notes with integrated applications or skills, as well as on device speech recognition for Alexa user requests.[45]

151. For example, the "Technical Details" on Amazon's website represent that the Echo Auto features "Wake word technology"—a technical term for a speech recognition system that detects a word or phrase, such as "Alexa" or "Echo," used to initiate a voice query to a voice-based digital assistant. Also, the website indicates that the Echo Auto is able to perform speech recognition functions even when the device is offline, such as through the "Local Voice Control extension, which ensures that customers get a reliable response from Alexa regardless of connectivity."[46]

152. On information and belief, the speech recognition circuit of the Accused Products works with cloud-based programming, natural language interpretation and other services with hardware-assisted on-device processing, creating a combination of hardware and software features.[47]

153. As to the first limitation of claim 1 of the '140 patent, the Accused Products contain one or more clusters of processors.

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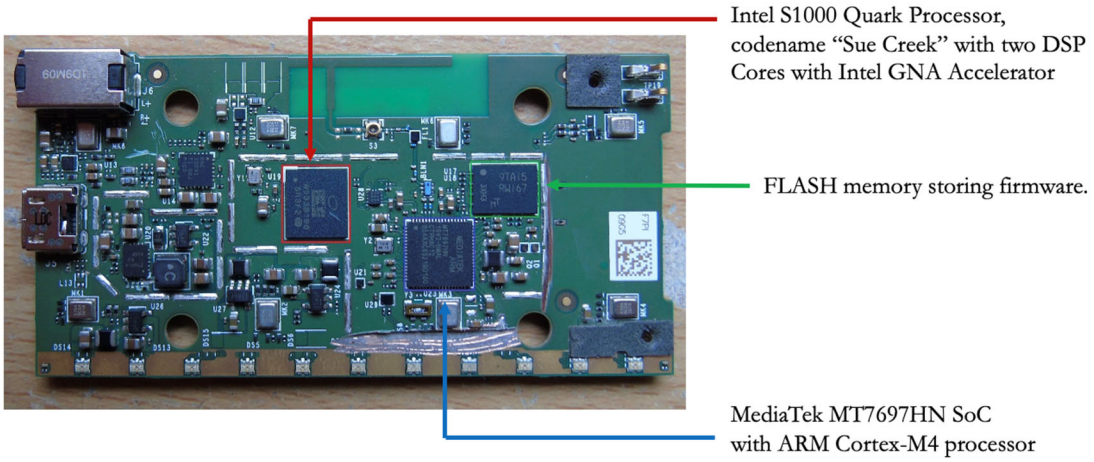
[45] *See* Alexa features, https://www.amazon.com/alexa-skills/b?ie=UTF8&node=13727921011 (describing various functionality as either "Alexa features" that are "something Alexa is able to do from the moment you turn on your Alexa-enabled device, to "Alexa skills," which are functions that require selection from the Skill store and to be enabled on device.)

[46] *See* Adam Foster, *Enabling Offline Access to Alexa in Vehicles with Local Voice Control Extension to Alexa Auto SDK v2.0*, (Sept. 10, 2019) https://developer.amazon.com/en-US/blogs/alexa/alexa-auto/2019/09/enabling-offline-access-to-alexa-in-vehicles-with-local-voice-control-extension-to-alexa-auto-sdk-v2-0.

[47] *See Intel Quark S1000 "Sue Creek" Processor to Support On-Chip Speech Recognition*, CNX Software (June 19, 2017), https://www.cnx-software.com/2017/06/19/intel-quark-s1000-sue-creek-processor-to-support-on-chip-speech-recognition (describing speech recognition capabilities of Sue Creek processor in certain Amazon Echo devices).



154. For example, the Echo Auto device includes an Intel Dual DSP with Inference Engine.[48] Based on an initial product teardown and as photographed above, the Echo Auto contains the Intel S1000 Quark Processor, codename "Sue Creek." The Sue Creek SoC contains the two DSP cores and an Intel Gaussian and Neural Accelerator (GNA) Inferencing Engine.

155. According to an Intel programing guide, "[t]he Intel Quark SoC S1000 ASIC is designed for complex far-field signal processing algorithms that use high dimensional microphone arrays to do beamforming, cancel echoes, and reduce noise. A pair of DSPs, a neural network accelerator, internal memory, and a set of I/Os provide the necessary resources for speech processing solutions."[49] The use of these resources for speech recognition was described by Intel authors in a paper presented at the Interspeech 2017 conference.[50]

[48] *See* Echo Auto Technical Details: Processor, https://www.amazon.com/dp/B07VTK654B?th=1.

[49] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

[50] *See* G. Stemmer et al., Speech Recognition and Understanding on Hardware-Accelerated DSP, Interspeech (2017).

156. The Accused Products further contain the second limitation of claim 1 of the '140 patent: notably, each of the cluster of processors comprises a plurality of processors. Notably, as described above, the Intel S1000 SoC is a cluster of processors. It contains, at least, the pair of DSPs and the GNA described above as providing the necessary "resources for speech processing solutions."[51]

157. The Accused Products further contain the third limitation of claim 1 of the '140 patent as well—an acoustic model memory storing acoustic model data, wherein each of the plurality of processors is configured to calculate a probability using the acoustic model data in the acoustic model memory.

158. By way of non-limiting example, among other processors in the Echo Auto device, the plurality of processors in the Intel S1000 SoC are configured for "speech processing solutions." [52] These solutions include probability calculations using acoustic model data in an acoustic model memory. Intel's Interspeech 2017 paper describes such a model when it states that "acoustic models are trained using the Kaldi open source toolkit on several thousands of hours of manually and semi-automatically transcribed speech data." In addition, Intel employees describe in a poster presented at ICAASP, an "[a]coustic model: 6-layer DNN w/ 2048 hidden nodes trained on 3000 hrs" and that "[a]coustic likelihood scoring"—*i.e.* probability or distance calculations—can be performed on the DSPs and Intel GNA. [53]

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[51] *Id*.

[52] *See* Intel® Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

[53] *See* Michael Deisher, et al., ICASSP GNA poster presentation "Implementation of Efficient, Low Power Deep Neural Networks on Next-Generation Intel Client Platforms" (2017), https://sigport.org/sites/all/modules/pubdlcnt/pubdlcnt.php?fid=1610 (noting that GNA can be programmed to compute a range of mathematical functions which are used to implement Neural Network based acoustic models, such as Affine, Convolutional, etc.).

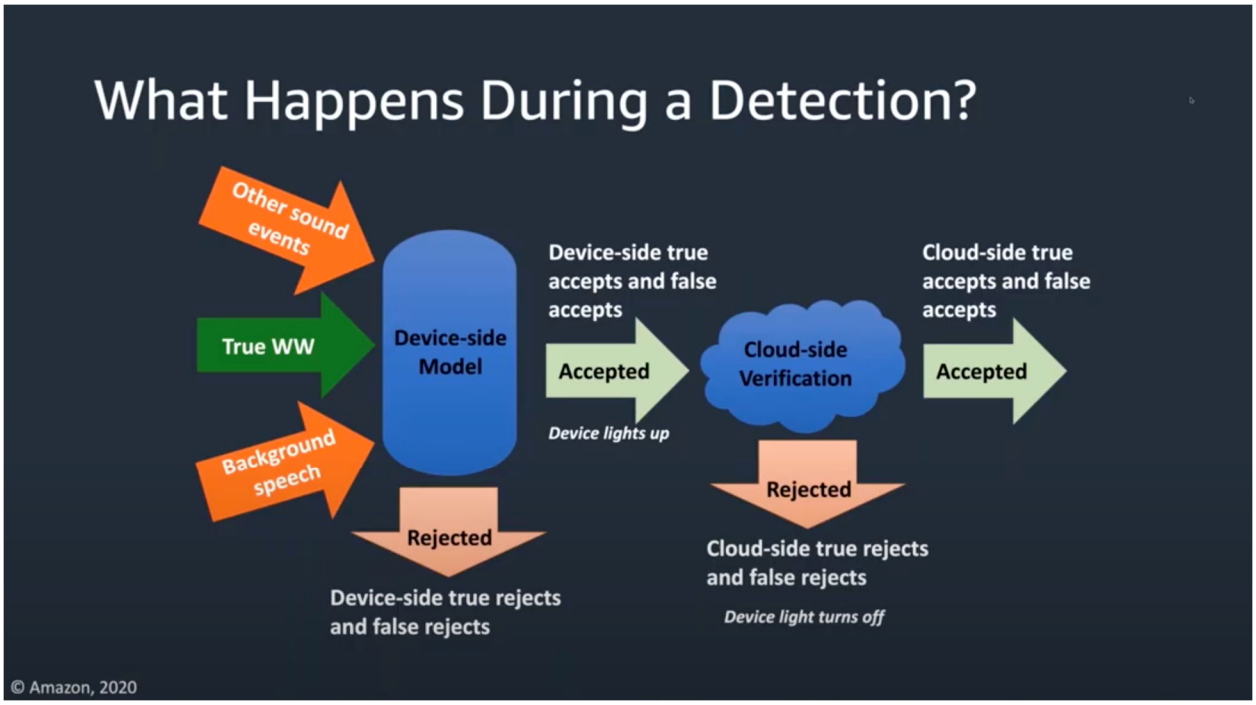
159. On information and belief, the acoustic model data described is stored in FLASH memory when the device is powered off and may be copied into other memory when the device powers up, in the form of on chip SRAM, DRAM, or cache memory (including the SRAM identified on the high-level block diagram above), the portions of each that hold acoustic model data being acoustic model memory.[54]

160. Moreover, the Accused Products contain the fourth and fifth limitations that the speech recognition circuit is configured to generate an initial score for an audio sample and that the initial score is used to determine whether to continue processing to determine a final score via processing a larger amount of model data than that which was processed to generate the initial score.

161. In an Amazon Alexa Speech Lightning Talk given in October 2020, the Director of Applied Science at Amazon Alexa, Shiv Vitaladevuni, described the speech recognition process of Amazon's Alexa devices with the following diagram.[55]

[54] *Id*.

[55] *See* Amazon Science, The Science Behind Alexa's Wake Word Detection at 5:43, available online at https://www.youtube.com/watch?v=kYrw2cC9dvs.



162. Notably, the diagram describes an initial "device-side model" that generates a score for an audio sample and determines whether to "accept" or "reject" the sample as including the "true wake word." If an "on-device accept" is determined, the audio sample is passed on to a second-level verification in the cloud with the increased compute resources present there.

163. On information and belief and based on the taped audio overlay of the Speech Lightning Talk, the subsequent "cloud-side verification" step contains a larger amount of acoustic model data than is used to calculate the initial on-device true (and false) accepts.[56]

164. Amazon actively, knowingly, and intentionally induces infringement of one or more claims of the '140 patent under 35 U.S.C. § 271(b) by actively encouraging others to make, use, sell, and offer to sell in the United States, the Accused Products.

165. For example, Amazon provides directions, instruction manuals, guides, and/or other materials that encourage and facilitate infringing use by others.

[56] *Id.* at 6 minutes and 54 seconds.

166. Amazon has sold and is selling the Accused Products with the knowledge and intent that customers who buy the products will use the products for their infringing use and therefore that customers have been and are directly infringing the '140 patent.

167. Amazon contributes to the infringement of one or more claims of the '140 patent under 35 U.S.C § 271(c) by offering to sell, selling, or importing into the United States, a component of the Accused Products that constitutes a material part of the inventions, knowing the same to be especially made or especially adapted for use in an infringement of the '140 patent, and is not a staple article or commodity of commerce suitable for substantial non-infringing use.

168. Amazon was aware of the '140 patent at least from the date of this Complaint.

169. On information and belief, Amazon has been aware of the '140 patent since its issuance on April 6, 2021.

170. On information and belief, Amazon knew that the Accused Products infringe the '140 patent, or at a minimum believed there was a high probability that the accused products were covered by Zentian's patents, but willfully blinded itself to Zentian's patents and the infringing nature of the Accused Products.

171. The foregoing allegations are based on publicly available information and a reasonable investigation of the structure and operation of the Accused Products.

172. Zentian reserves the right to modify this description of alleged infringement, including, for example, on the basis of information about the Accused Products that it obtains during discovery.

173. The infringement details provided for claim 1 of the '140 patent are exemplary, and Zentian intends to assert additional claims of the '140 patent beyond claim 1.

174. Amazon's infringement has damaged and continues to damage Zentian in an amount yet to be determined. At the very least, Zentian should receive a reasonable royalty for Amazon's unauthorized use of the claimed inventions set forth in the '140 patent.

175. This is an exceptional case. Zentian is entitled to attorneys' fees and costs under 35 U.S.C § 285 as a result of the infringement of the '140 patent by Amazon.

COUNT FOUR: INFRINGEMENT OF U.S. PATENT NO. 10,062,377

176. Zentian incorporates by reference and realleges the allegations in paragraphs 1-175.

177. The '377 patent is valid and enforceable.

178. The '377 patent names Guy Larri, Mark Catchpole, Damian Kelly Harris-Dowsett, and Timothy Brian Reynolds as inventors.

179. Amazon has directly infringed, continues to infringe, and has induced or contributed to the infringement of the '377 patent by making, using, selling, and offering for sale in the United States, and importing into the United States, without authority or license the Accused Products in violation of 35 U.SC. § 271(a).

180. The Accused Products are non-limiting examples identified based on publicly available information. Zentian reserves the right to identify additional infringing activities, products, and services, including, for example, on the basis of information obtained during discovery.

181. By way of example only, the Accused Products meet all the limitations of at least independent claim 1 of the '377 patent, and dependent claims 2-6, either literally or under the doctrine of equivalents.

182. Claim 1 of the '377 patent recites:

A speech recognition system comprising:

> [1] a first programmable device programmed to calculate a feature vector from a digital audio stream, wherein the feature vector comprises a plurality of extracted and/or derived quantities from said digital audio stream during a defined audio time frame;
>
> [2] a second programmable device programmed to calculate distances indicating the similarity between a feature vector and a plurality of acoustic states of an acoustic model wherein said feature vector is received by the second programmable device after it is calculated by the first programmable device; and
>
> [3] a third programmable device programmed to identify the spoken words in said digital audio stream using Hidden Markov Models and/or Neural Networks wherein said word identification uses one or more distances that were calculated by the second programmable device, wherein said identification of spoken words uses one or more distances calculated from a first feature vector; and
>
> [4] a search stage for using the calculated distances to identify words within a lexical tree, the lexical tree comprising a model of words.

183. Regarding the preamble of claim 1, to the extent the preamble is determined to be limiting, the Accused Products contain a speech recognition system that allows for device users to speak the words "Alexa," "Amazon," "Computer," or "Echo," and activate Amazon's personal assistant, hands-free. The speech recognition system of the Accused Products further allows for dictation of text messages and notes with integrated applications or skills, as well as on device speech recognition for Alexa user requests.[57]

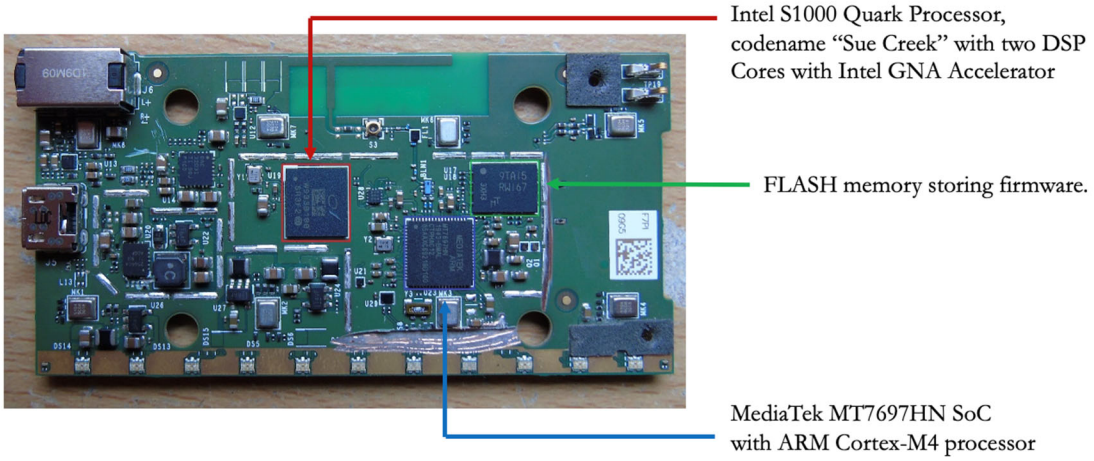
184. For example, the "Technical Details" on Amazon's website represent that the Echo Auto features "Wake word technology"— a technical term for a speech recognition system that detects a word or phrase, such as "Alexa" or "Echo," used to initiate a voice query to a voice-based digital assistant. Also, the website indicates that the Echo Auto is able to perform speech recognition functions even when the device is offline, such as through the "Local Voice Control

[57] *See* Alexa features, https://www.amazon.com/alexa-skills/b?ie=UTF8&node=13727921011 (describing various functionality as either "Alexa features" that are "something Alexa is able to do from the moment you turn on your Alexa-enabled device, to "Alexa skills," which are functions that require selection from the Skill store and to be enabled on device.)

extension, which ensures that customers get a reliable response from Alexa regardless of connectivity."[58]

185. On information and belief, the speech recognition system of the Accused Products works with cloud-based programming, natural language interpretation and other services with hardware-assisted on-device processing, creating a combination of hardware and software features.[59]

186. As to the first limitation of claim 1 of the '377 patent, the Accused Products contain a first programmable device programmed to calculate a feature vector from a digital audio stream, wherein the feature vector comprises a plurality of extracted and/or derived quantities from said digital audio stream during a defined audio time frame.



[58] *See* Adam Foster, *Enabling Offline Access to Alexa in Vehicles with Local Voice Control Extension to Alexa Auto SDK v2.0* (Sept. 10, 2019), https://developer.amazon.com/en-US/blogs/alexa/alexa-auto/2019/09/enabling-offline-access-to-alexa-in-vehicles-with-local-voice-control-extension-to-alexa-auto-sdk-v2-0.

[59] *See Intel Quark S1000 "Sue Creek" Processor to Support On-Chip Speech Recognition*, CNX Software (June 19, 2017), https://www.cnx-software.com/2017/06/19/intel-quark-s1000-sue-creek-processor-to-support-on-chip-speech-recognition (describing speech recognition capabilities of Sue Creek processor in certain Amazon Echo devices).

187. For example, the Echo Auto device includes an Intel Dual DSP with Inference Engine, along with an eight-microphone array.[60] Based on an initial product teardown and as photographed above, the Echo Auto also contains the Intel S1000 Quark Processor, codename "Sue Creek." The Sue Creek SoC contains two DSP cores and an Intel Gaussian and Neural Accelerator (GNA) Inferencing Engine. The Echo Auto also contains Flash memory for storing firmware and model data used by the speech recognition process.

188. According to an Intel programing guide, "[t]he Intel Quark SoC S1000 ASIC is designed for complex far-field signal processing algorithms that use high dimensional microphone arrays to do beamforming, cancel echoes, and reduce noise. A pair of DSPs, a neural network accelerator, internal memory, and a set of I/Os provide the necessary resources for speech processing solutions."[61]

189. Moreover, as shown in the below figure from the Intel Quark™ SoC S1000 Firmware Programming Guide, the overall speech recognition system operates on a series of "frames," where processing performs a "loop for every frame N." One of the DSP cores operates as a first programmable device programmed to calculate feature vectors from the digital audio stream formed from the eight-microphone array that is incorporated into the Echo Auto. Feature vectors comprise a plurality of extracted and/or derived quantities during a defined audio time frame.[62]

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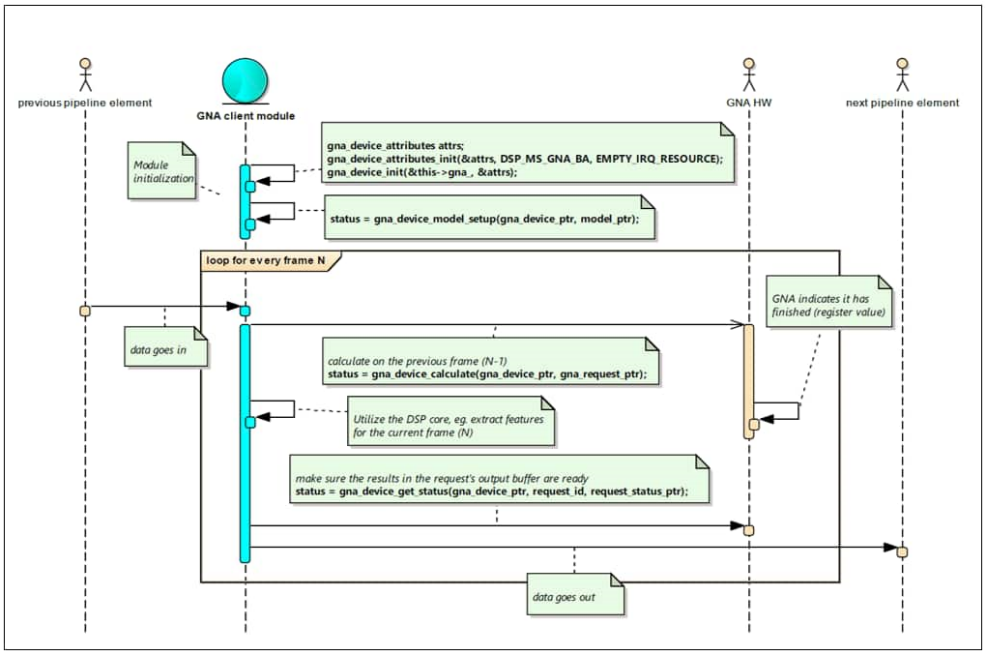
[60] *See* Echo Auto Technical Details: Processor, https://www.amazon.com/dp/B07VTK654B?th=1.

[61] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

[62] *Id*.



190. The Accused Products contain the second limitation of claim 1 of the '377 patent: notably, the Echo Auto includes a second programmable device programmed to calculate distances (*i.e.*, probabilities) indicating the similarity between the feature vector received from the first programmable device and a plurality of acoustic states of an acoustic model.

191. In the case of the Amazon Echo Auto, the second programmable device is the Gaussian and Neural Accelerator within the Intel Quark S1000 SoC. The Intel GNA is a "flexible, low-power, high performance streaming co-processor that offloads neural network inference operations from the DSP and application processor."[63] The Intel GNA is programmed to compute Gaussian Mixtures, which compute distances between feature vectors and a plurality of acoustic states in an acoustic model.[64] As illustrated in the above figure from Intel Quark™ SoC S1000

[63] *See* G. Stemmer et al., Speech Recognition and Understanding on Hardware-Accelerated DSP, Interspeech (2017).

[64] *See* Michael Deisher, et al., ICASSP GNA poster presentation "Implementation of Efficient, Low Power Deep Neural Networks on Next-Generation Intel Client Platforms" (2017), https://sigport.org/sites/all/modules/pubdlcnt/pubdlcnt.php?fid=1610 (noting that GNA can be

Firmware Programming Guide, the GNA receives feature vectors after they have been calculated on the DSP core.[65]

192. The Accused Products contain the third limitation of claim 1 of the '377 patent as well—a third programmable device programmed to identify spoken words in a digital audio stream using either a Hidden Markov Model and/or a Neural Network. The identification of spoken words by the third programmable device uses one or more of the distances calculated by the second programmable device, which themselves were calculated from the feature vectors calculated by the first programmable device.

193. Again, by way of example only, the Echo Auto includes a third programmable device—namely, the second DSP core in the Sue Creek SoC—programmed to identify spoken words in said digital audio stream. The Automatic Speech Recognition (ASR) engine that runs on the Sue Creek processor uses the distances calculated by the GNA to accelerate the speech recognition process and uses Neural Networks based models, such as "Affine, Convolutional, Guassian Mix, etc." (described as "Layer types" in the excerpted figure below) to identify spoken words, such as "Alexa," in the digital audio stream. [66]

programmed to compute a range of mathematical functions which are used to implement Neural Network based acoustic models, such as Affine, Convolutional, etc.).

[65] *See* Intel® Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

[66] *See* Michael Deisher, et al., ICASSP GNA poster presentation "Implementation of Efficient, Low Power Deep Neural Networks on Next-Generation Intel Client Platforms" (2017), https://sigport.org/sites/all/modules/pubdlcnt/pubdlcnt.php?fid=1610

How does GNA work?

Neural network topology stored in memory as list of layer descriptors

Layer types: affine, diagonal affine, Gaussian mixture model, recurrent, convolutional1D, transpose, copy

Activation function: piecewise linear (PWL) approximation

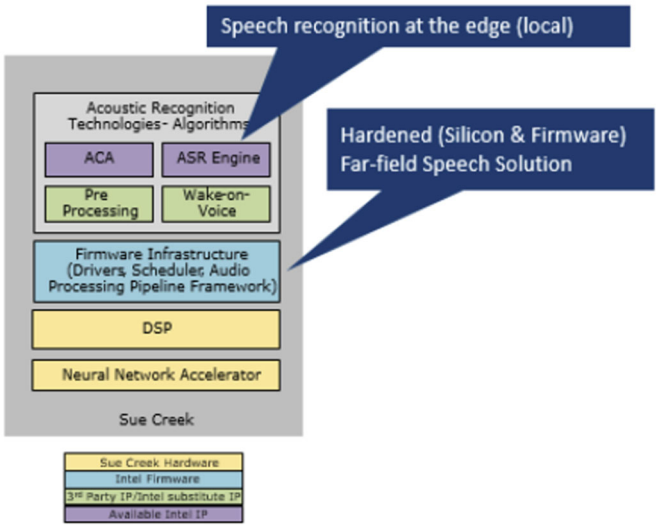
Layer Type	Input Orientation	Output Orientation	Batch Size	Weight Width	PWL Activation	Partial Output
Affine	column vector	column vector	1-8	1B, 2B	optional	yes
Diagonal Affine	column vector	column vector	1-8	1B, 2B	optional	no
Convolutional	row vector	row vector	1	2B	optional	no
Gaussian Mix	column vector	column vector	1-8	1B	no	yes
Recurrent	row vector	row vector	1-8	1B, 2B	required	no
Copy	row vector	row vector	1-8	N/A	N/A	no
Interleave	row vector	column vector	1-8	N/A	N/A	no
Deinterleave	column vector	row vector	1-8	N/A	N/A	no

194. Moreover, the Accused Products contain the fourth and final limitation of claim 1 of the '377 patent—a search stage for using the calculated distances to identify words within a lexical tree, the lexical tree comprising a model of words.

195. On information and belief, in the Amazon Echo Auto device, the search stage of the speech recognition system is implemented in software running on the second DSP core in the Intel Sue Creek SoC. The search stage uses distances calculated by the Intel GNA to identify multiple pronunciations of words such as "Alexa," "Computer," and "Echo." The set of recognized wake word pronunciations is stored in the speech recognition software as a model of words, which comprises a lexical tree.[67]

[67] *See e.g., Intel Quark S1000 "Sue Creek" Processor to Support On-Chip Speech Recognition*, CNX Software (June 19, 2017), https://www.cnx-software.com/2017/06/19/intel-quark-s1000-sue-creek-processor-to-support-on-chip-speech-recognition.

196. Further support for this appears in an article that describes the capabilities of the Sue Creek processor to perform speech recognition "at the edge (local)." It states that the "Intel processor can handle some speech recognition, likely for a limited subset of words, and use cloud-based recognition for more complex requests."[68] The diagram contained therein and depicted on the right explains that the speech recognition technologies performed on-device are a combination of "3rd party IP/Intel substitute IP" and/or "Available Intel IP", as opposed to "Intel Firmware" and/or "Sue Creek Hardware.") Notably, the "ASR" in "ASR Engine" stands for "Automatic Speech Recognition." In other words, the Sue Creek processor performs a search for wake words using some form of model of words that is either created by third parties, such as Amazon, or is a selected option from "Intel IP."[69]



197. Amazon actively, knowingly, and intentionally induces infringement of one or more claims of the '377 patent under 35 U.S.C. § 271(b) by actively encouraging others to make, use, sell, and offer to sell in the United States, the Accused Products.

198. For example, Amazon provides directions, instruction manuals, guides, and/or other materials that encourage and facilitate infringing use by others.

[68] *Id.*

[69] *Id.*

199. Amazon has sold and is selling the Accused Products with the knowledge and intent that customers who buy the products will use the products for their infringing use and therefore that customers have been and are directly infringing the ’377 patent.

200. Amazon contributes to the infringement of one or more claims of the ’377 patent under 35 U.S.C § 271(c) by offering to sell, selling, or importing into the United States, a component of the Accused Products that constitutes a material part of the inventions, knowing the same to be especially made or especially adapted for use in an infringement of the ’377 patent, and is not a staple article or commodity of commerce suitable for substantial non-infringing use.

201. Amazon was aware of the ’377 patent at least from the date of this Complaint.

202. On information and belief, Amazon has been aware of the ’377 patent since its issuance on August 28, 2018.

203. On information and belief, Amazon knew that the Accused Products infringe the ’377 patent, or at a minimum believed there was a high probability that the accused products were covered by Zentian's patents, but willfully blinded itself to Zentian's patents and the infringing nature of the Accused Products.

204. The foregoing allegations are based on publicly available information and a reasonable investigation of the structure and operation of the Accused Products.

205. Zentian reserves the right to modify this description of alleged infringement, including, for example, on the basis of information about the Accused Products that it obtains during discovery.

206. The infringement details provided for claim 1 of the ’377 patent are exemplary, and Zentian intends to assert additional claims of the ’377 patent beyond claim 1.

207. Amazon's infringement has damaged and continues to damage Zentian in an amount yet to be determined. At the very least, Zentian should receive a reasonable royalty for Amazon's unauthorized use of the claimed inventions set forth in the '377 patent.

208. This is an exceptional case. Zentian is entitled to attorneys' fees and costs under 35 U.S.C § 285 as a result of the infringement of the '377 patent by Amazon.

COUNT FIVE: INFRINGEMENT OF U.S. PATENT NO. 10,839, 789

209. Zentian incorporates by reference and realleges the allegations in paragraphs 1-208.

210. The '789 patent is valid and enforceable.

211. The '789 patent names Guy Larri, Mark Catchpole, Damian Kelly Harris-Dowsett, and Timothy Brian Reynolds as inventors.

212. Amazon has directly infringed, continues to infringe, and has induced or contributed to the infringement of the '789 patent by making, using, selling, and offering for sale in the United States, and importing into the United States, without authority or license the Accused Products in violation of 35 U.SC. § 271(a).

213. The Accused Products are non-limiting examples identified based on publicly available information. Zentian reserves the right to identify additional infringing activities, products, and services, including, for example, on the basis of information obtained during discovery.

214. By way of example only, the Accused Products meet all the limitations of at least claim 10 of the '789 patent, either literally or under the doctrine of equivalents, which recites:

An acoustic coprocessor, comprising:

[1] a first interface for receiving at least one feature vector:

[2] a calculating apparatus for calculating distances indicating a similarity between the at least one feature vector and at least one acoustic state of an acoustic model read from an acoustic model memory; and

[3] a second interface sending at least one distance calculated by the calculating apparatus.

215. Regarding the preamble of claim 10, to the extent the preamble is determined to be limiting, the Accused Products contain an acoustic coprocessor. For example, the Echo Auto and Echo Show devices contain an Intel Gaussian and Neural Accelerator (GNA).

216. According to Intel, the GNA "delivers a dedicated engine for background workloads such as voice processing and noise suppression at ultra-low power, for maximum battery life."[70]

217. The Intel GNA is located on, among other Intel SoCs, the Intel S1000 ASIC, which is known as the "Sue Creek" processor and is included in the Amazon Echo Auto device, for example. An annotated high-level block diagram of the Sue Creek processor is below. It shows the presence of the Intel GNA, along with two DSP cores, internal memory, and a set of I/Os, all of which "provide the necessary resources for speech processing solutions."[71]

[70] *See* Intel Newsroom, *Intel Launches First 10th Gen Intel Core Processors: Redefining the Next Era of Laptop Experiences* (Aug. 1, 2019), https://newsroom.intel.com/news/intel-launches-first-10th-gen-intel-core-processors-redefining-next-era-laptop-experiences/#gs.iwvy00.

[71] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000

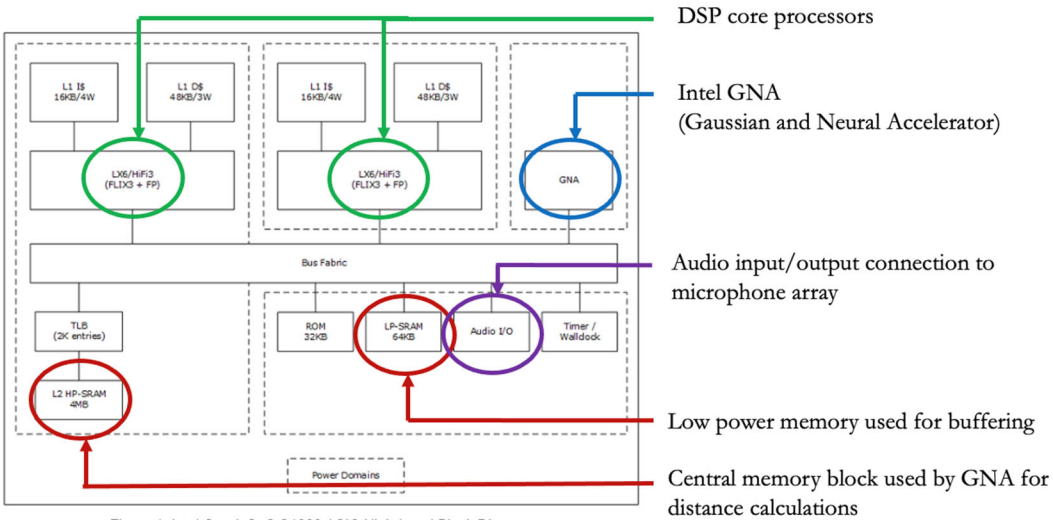


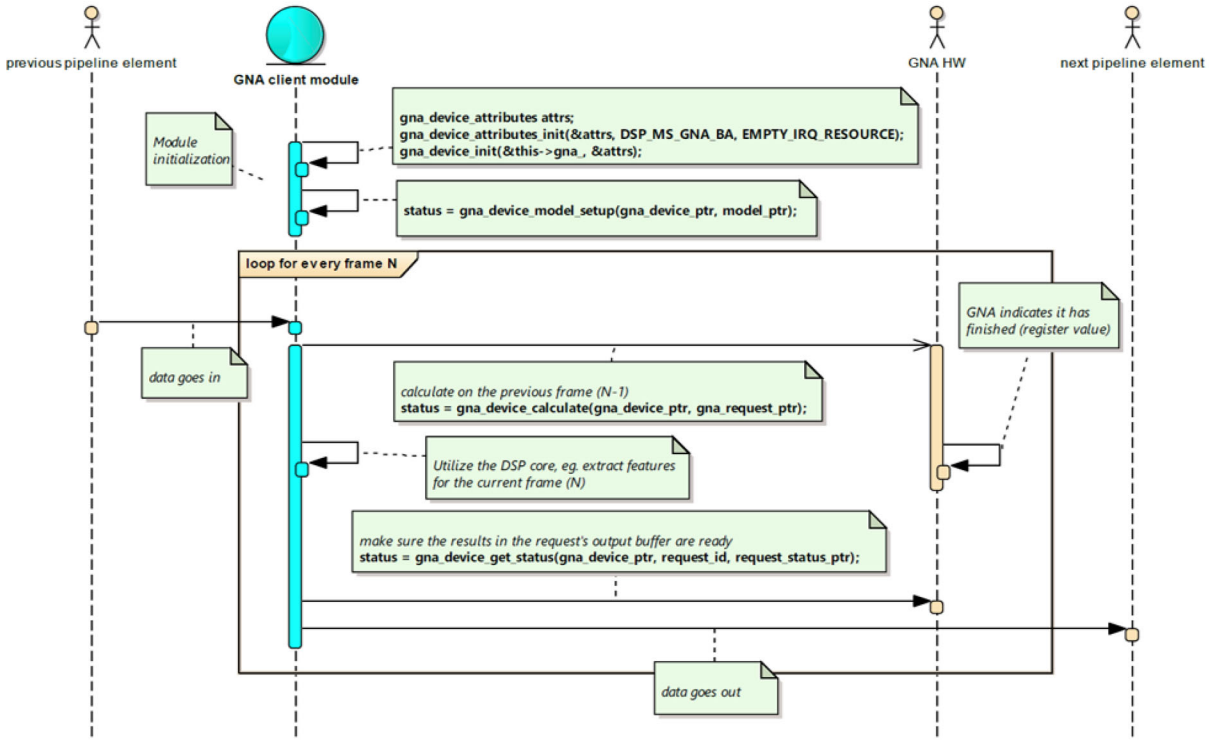
Figure 1. Intel Quark SoC S1000 ASIC High-Level Block Diagram

218. In a paper presented at Interspeech 2017, Intel authors described the GNA as a co-processor: "GNA is a "flexible, low-power, high performance streaming co-processor that offloads neural network inference operations from the DSP and application processor."[72]

219. As further explained by Intel, the GNA is capable of utilizing extracted features from the DSP core that were calculated earlier for frame (N-1) to calculate the acoustic model

[72] *See* G. Stemmer et al., Speech Recognition and Understanding on Hardware-Accelerated DSP, Interspeech (2017).

outputs for Frame (N-1), while the DSP calculates feature vectors for the next frame (N), such that the GNA is processing one frame behind the DSP.[73]



220. In other words, the Intel GNA processes feature vectors associated with audio signals received from the microphones (via the DSP) and is, in turn, an acoustic coprocessor.

[73] *See* Intel Quark™ SoC S1000 Firmware Programming Guide at Figure 47, https://www.intel.com/content/www/us/en/developer/articles/guide/firmware-programming-guide-s1000.html.

221. As to the first limitation of claim 10 of the '789 patent, the Accused Products contain a first interface for receiving at least one feature vector. Specifically, the block diagram at right, shows the Intel GNA with an interface for receiving feature vectors from an audio signal, shown as the end point of arrows from data arrays and network parameter arrays to input data buffers designed to "hold inputs…of each layer."[74]

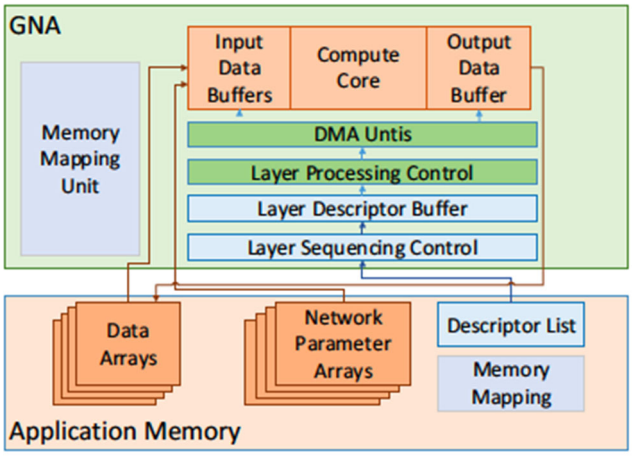


Figure 2: *GNA block diagram and memory organization*

222. The Accused Products also contain the second limitation of claim 10 of the '789 patent. On information and belief, the "compute core" of the Intel GNA, depicted in the figure above between the "Input Data Buffer" and "Output Data Buffer" is a calculating apparatus for calculating distances indicating a similarity between feature vectors and acoustic states of an acoustic model, read from an acoustic memory.

223. At the 2017 International Conference of Acoustics, Speech, and Signal Processing (ICASSP), representatives of Intel demonstrated the GNA performing "continuous acoustic model likelihood scoring" using a 6-layer DNN with 2048 hidden nodes acoustic model. The demonstration showed the utility of the Intel GNA for highly accurate, low power, speech recognition compared to the application processor itself.[75]

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[74] *See* G. Stemmer et al., *Speech Recognition and Understanding on Hardware-Accelerated DSP*, Interspeech (2017) at Figure 2.

[75] *See* Michael Deisher and Andrzej Polonsky, *Implementation of Efficient, Low Power Deep Neural Networks on Next-Generation Intel Client Platforms*, ICASSP (Apr. 12, 2017),

224. Moreover, the compute core of the GNA retrieves the acoustic model from an acoustic model memory. This is shown in the annotated high-level block diagram above as "L2 HP-SRAM, 4MB" and described in the firmware programming guide as "4 MB of internal high-performance memory is the central memory" that is accessible to both the DSP cores and GNA engine.[76]

225. The Accused Products further contain the third limitation of claim 10 of the '789 patent, a second interface for sending at least one distance calculated by the calculating apparatus. Returning to the diagram included above captioned "Figure 2: *GNA block diagram and memory organization*," a second interface for sending distances calculated by the "Compute Core" is shown as the starting point of an arrow from the output data buffer to the "Data Arrays."[77] The Output Data Buffers hold the outputs of each layer, and hence hold the outputs of the acoustic model, which are the outputs of the final layer.[78]

226. Amazon actively, knowingly, and intentionally induces infringement of one or more claims of the '789 patent under 35 U.S.C. § 271(b) by actively encouraging others to make, use, sell, and offer to sell in the United States, the Accused Products.

227. For example, Amazon provides directions, instruction manuals, guides, and/or other materials that encourage and facilitate infringing use by others.

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https://sigport.org/documents/implementation-efficient-low-power-deep-neural-networks-next-generation-intel-client.

[76] *See* Intel Quark™ SoC S1000 Firmware Programming Guide, https://software.intel.com/en-us/articles/firmware-programming-guide-s1000.

[77] *Id*.

[78] *Id*.

228. Amazon has sold and is selling the Accused Products with the knowledge and intent that customers who buy the products will use the products for their infringing use and therefore that customers have been and are directly infringing the '789 patent.

229. Amazon contributes to the infringement of one or more claims of the '789 patent under 35 U.S.C § 271(c) by offering to sell, selling, or importing into the United States, a component of the Accused Products that constitutes a material part of the inventions, knowing the same to be especially made or especially adapted for use in an infringement of the '789 patent, and is not a staple article or commodity of commerce suitable for substantial non-infringing use.

230. Amazon was aware of the '789 patent at least from the date of this Complaint.

231. On information and belief, Amazon has been aware of the '789 patent since its issuance on November 17, 2020.

232. On information and belief, Amazon knew that the Accused Products infringe the '789 patent, or at a minimum believed there was a high probability that the accused products were covered by Zentian's patents, but willfully blinded itself to Zentian's patents and the infringing nature of the Accused Products.

233. The foregoing allegations are based on publicly available information and a reasonable investigation of the structure and operation of the Accused Products.

234. Zentian reserves the right to modify this description of alleged infringement, including, for example, on the basis of information about the Accused Products that it obtains during discovery.

235. The infringement details provided for claim 10 of the '789 patent are exemplary, and Zentian intends to assert additional claims of the '789 patent beyond claim 10.

236. Amazon's infringement has damaged and continues to damage Zentian in an amount yet to be determined. At the very least, Zentian should receive a reasonable royalty for Amazon's unauthorized use of the claimed inventions set forth in the '789 patent.

237. This is an exceptional case. Zentian is entitled to attorneys' fees and costs under 35 U.S.C § 285 as a result of the infringement of the '789 patent by Amazon.

JURY DEMAND

238. Zentian requests a trial by jury on all issues so triable under Federal Rule of Civil Procedure 38.

PRAYER FOR RELIEF

WHEREFORE, Zentian respectfully requests the following:

A. That Judgment be entered that Amazon has infringed one or more claims of each of the Asserted Patents, directly and indirectly, literally and/or under the doctrine of equivalents;

B. An award of damages sufficient to compensate Zentian for Amazon's infringement under 35 U.S.C. § 284, including an enhancement of damages on account of Amazon's willful infringement;

C. That the case be found exceptional under 35 U.S.C. § 285 and that Zentian be awarded its reasonable attorneys' fees;

D. Costs and expenses in this action;

E. An award of prejudgment and post-judgment interest; and

F. Such other and further relief as the Court may deem just and proper

Dated: February 2, 2022

/s/ Jonathon K. Hance

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