UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMERICAN AIRLINES, INC. AND SOUTHWEST AIRLINES CO.,

Petitioners

v.

INTELLECTUAL VENTURES I LLC,

Patent Owner.

IPR2025-01055
U.S. Patent No. 8,027,326

DECLARATION OF DR. CHUCK EASTTOM Ph.D., D.Sc.

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I. INTRODUCTION

1. My name is William C. Easttom II (Chuck Easttom). I have 30 years of experience in the computer science and computer networking industry including extensive experience with computer science including parallel and distributed programming as well as multi-threaded programming. I have authored 44 computer science books, including textbooks used at over 60 universities around the world. I also have authored over 70 research papers and am an inventor with 27 computer science patents.

2. The following list is a sample of my publications related to computer networking:

- Easttom, C. (2006). Network Defense and Countermeasures. New York City, New York: Pearson Press.
- Easttom, C. & Roberts, R. (2018). Networking Fundamentals, 3rd Edition. Goodheart-Wilcox Publishing
- Easttom, C. (2022). Networking Fundamentals, 4th Edition. Goodheart-Wilcox Publishing.
- Easttom, C. (2020). On the Application of Algebraic Graph Theory to Modeling Network Intrusions. 2020 IEEE 10th Annual Computing and Communication Conference.

- Easttom, C. Adda, M. (2020) The Creation of Network Intrusion Fingerprints by Graph Homomorphism. WSEAS Transactions on Information Science and Applications. 17(2020). DOI: 10.37394/23209.2020.17.15
- U.S. Patent No. 8,825,845 B1 Managing a network element operating on a network.

3. I hold over 80 industry certifications. The following is a sample of the certifications I hold that are related to computer networking:

- CompTIA Network + Certified COMP10163630.
- JN0-103 Juniper Networks Certified Associate, Junos JNCIA-Junos
- Cisco 100-490 Supporting Cisco Routing and Switching Network Devices
- CompTIA Network Infrastructure Professional – CNIP COMP10163630
- CompTIA Linux Network Professional – CLNP COMP10163630

4. I hold a Doctor of Science (D.Sc.) degree in Cyber Security from Capitol Technology University (Dissertation Topic: "A Comparative Study of Lattice Based Algorithms for Post Quantum Computing"). I also hold a Doctor of Philosophy (Ph.D.) in Technology focused on nanotechnology (Dissertation Topic: "The Effects

of Complexity on Carbon Nanotube Failures") from Capitol Technology University. I also have a Doctor of Philosophy (Ph.D.) in Computer Science from the University of Portsmouth (Dissertation Topic: "A Systematic Framework for Network Forensics Using Graph Theory"). I also have four master's degrees (one in Applied Computer Science, one in Education, one in Strategic and Defense Studies, and one in Systems Engineering).

5. I am currently an Adjunct Lecturer for Georgetown teaching graduate courses in requirements engineering, cybersecurity, artificial intelligence, and cryptography. I am also an adjunct at Vanderbilt University teaching graduate computer science courses, specifically quantum computing, secure software engineering, and digital forensics. I also developed a graduate course in digital forensics for the University of Dallas and taught that course from 2019 to 2022.

6. I am a Senior member and Distinguished Speaker for the Association of Computing Machinery (ACM) and a Senior Member and Distinguished Visitor of the Institute for Electrical and Electronics Engineering (IEEE). The IEEE is the world's largest and most preeminent engineering organization. Among other activities, the IEEE creates industry standards for a wide range of engineering disciplines, including software development standards. I am also a Distinguished Visitor of the IEEE. I have been involved in IEEE standards creation for several years.

7. My full CV is included as Exhibit 1005.

8. I am being compensated at my usual rate of $550 per hour. My compensation is not dependent in any way upon my conclusions or the outcome of this matter.

II. LEGAL STANDARDS

9. In forming my analysis and conclusions expressed in this Declaration, I have applied the legal principles described in the following paragraphs, which were provided to me by counsel for the Petitioners.

A. Validity

10. I understand that each claim of a patent is presumed to be valid. Dependent claims shall also be presumed valid even if they depend upon an invalid claim.

11. 35 U.S. Code § 282 states, "[a] patent shall be presumed valid. Each claim of a patent (whether in independent, dependent, or multiple dependent form) shall be presumed valid independently of the validity of other claims; dependent or multiple dependent claims shall be presumed valid even though dependent upon an invalid claim. The burden of establishing invalidity of a patent or any claim thereof shall rest on the party asserting such invalidity."

B. Obviousness

12. I understand that a patent claim is invalid if the differences between the subject matter and the prior art are such that the subject matter as a whole would have been obvious to a person of skill in the art, or POSITA, at the time of the alleged invention.

I further understand that an obviousness analysis involves a review of the scope and content of the asserted prior art; the differences between the prior art and the claims at issue; the level of ordinary skill in the pertinent art; and objective indicia of non-obviousness (i.e., secondary considerations), such as long-felt but unsolved needs, failure of others, industry praise, commercial success, and skepticism of others in the field.

13. In determining obviousness based on a combination of prior art references, I also understand that evidence of a reason to combine the teachings is required to make the combination. Any evidence that one or more of the references would have taught away from the claimed invention at the time of the invention must also be considered.

14. I have been informed that the following rationales, among others, may support a conclusion of obviousness:

i. the combination of familiar elements according to known methods to yield predictable results;

ii. the simple substitution of one known element for another to obtain predictable results;

iii. the use of known techniques to improve similar methods or apparatuses in the same way;

iv. the application of a known technique to a known method or apparatus ready for improvement to yield predictable results;

v. the choice of a particular solution from a finite number of identified, predictable solutions with a reasonable expectation of success;

vi. the use of known work in one field of endeavor in either the same field or a different one based on design incentives or other market forces, if the variations are predictable to one of ordinary skill in the art; and

vii. the following of some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention

15. I also understand that secondary considerations such as long-felt but unsolved needs, failure of others, praise, skepticism, and commercial success are relevant to determining obviousness.

16. I understand that there must be evidence showing an articulated reasoning with rational underpinnings to support a motivation to combine teachings and to support the legal conclusion of obviousness. However, I understand that proposed modifications which would render the prior art unsatisfactory for its intended purposes or change the principal operation of the reference do not render a claim obvious.

17. Moreover, if prior art indicates that the invention would not have worked for its intended purpose, or otherwise teaches away from the invention, then a claim would not be obvious. A reference teaches away when a POSITA, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken in the claim.

C. Motivation to Combine

18. It is my understanding that a motivation to combine must meet certain requirements. It is not sufficient for an expert to simply state there is a motivation to combine. Instead, there must be a clearly articulated reason to combine. In order to satisfy these requirements, the articulated motivation to combine should include the following:

i. the prior art included each element claimed, although not necessarily in a single prior art reference, with the only difference between the claimed invention and the prior art being the lack of actual combination of the elements in a single prior art reference;

ii. one of ordinary skill in the art could have combined the elements as claimed by known methods, and that in combination, each element merely performs the same function as it does separately; and

iii. one of ordinary skill in the art would have recognized that the results of the combination were predictable.

D. Claim Construction

19. I understand that, for purposes of my analysis in this inter partes review proceeding, the terms appearing in the patent claims should be interpreted according to their "ordinary and customary meaning." In determining the ordinary and customary meaning, I understand that the words of a claim are first given their plain meaning that those words would have had to a person of ordinary skill in the art at the time of the alleged invention. I also understand that the structure of the claims, the specification and file history may be used to better construe a claim. Moreover, I understand that even treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by a person of ordinary skill in the art to a claim term. To the extent that the meaning of any claim term would not be self-evident to a layperson, I explain the understanding of a POSITA relating to satisfaction of the claim limitation including that claim term below.

III. ANALYSIS

20. This section contains my analysis of U.S. Patent 8,027,326 ('326 patent) and its validity or invalidity in light of cited prior art.

A. U.S. Patent 8,027,326

21. The '326 patent was granted September 27, 2011, filed January 12, 2005, and claims priority to January 12, 2004. The '326 patent describes itself as being

generally directed to high data rate expanded bandwidth (wide band) WLAN 'operations reusing existing single channel radio designs. Ex.1001, Abstract.

1. Level of Ordinary Skill in the Art for '326 patent

22. In determining the level of one of ordinary skill in the art, I considered the '326 patent itself, the state of the art at the time of the invention (which I assume for the purposes of this declaration is no earlier than January 12, 2004), and the prior art referenced in the '326 patent itself.

23. A person of ordinary skill in the art as of the '326 patent's earliest priority claim would have a bachelor's degree in an academic area emphasizing computer networking (i.e., computer science, computer information systems, computer engineering, etc.) and (2) at least two years of work experience with wireless network traffic, with additional education substituting for less experience and vice versa. For example, someone with a relevant master's degree and 1 year of experience could qualify as one of ordinary skill in the art. Similarly, someone with no degree but five years of relevant experience might qualify as one of ordinary skill in the art.

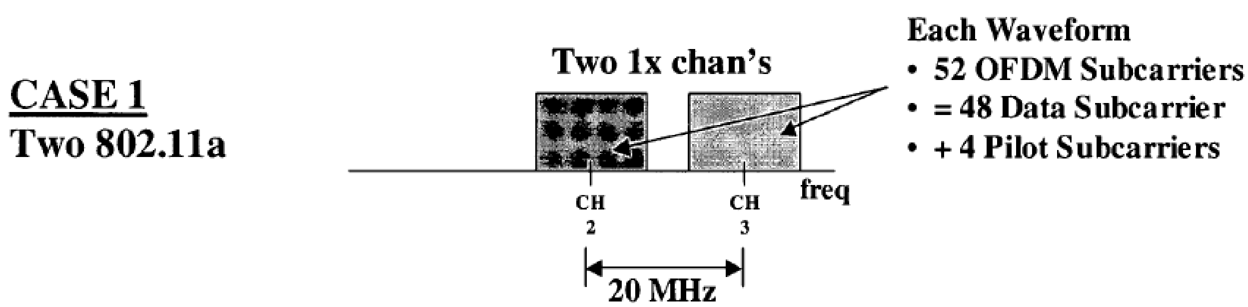
2. Overview of the '326 patent

24. The '326 patent relates to the well-known concept of grouping of wireless signal subcarriers (frequencies) to form a "channel" over which an orthogonal frequency division multiplexing (OFDM) symbol is transmitted and received. The

‘326 patent proposes extensions for the IEEE 802.11a/g standard, for use in IEEE 802.11n. Ex.1001, 2:31-48, 4:65-5:15, 5:26-27, 5:33-35, 8:46-55.

25. Fundamentally, the ‘326 Patent relates to the number of subcarriers within channel(s) used to carry data—for example, 96, 108, or 120 data subcarriers rather than just the 48 data subcarriers used under the IEEE 802.11a/g standard. Ex.1001, 10:31-36, 10:43-47.

26. As described in the ‘326 Patent, each channel under IEEE 802.11a/g includes equally spaced (in the frequency domain) subcarriers, with the center frequencies of adjacent channels (“CH2”and “CH3,” below) separated by 20MHz:



Ex.1001, Fig. 4 (“Case 1”), 10:30-31. Each channel under IEEE 802.11a/g includes 48 subcarriers for carrying data, 4 subcarriers for pilot signals that each carry known values used to estimate channel coefficients, and subcarriers at each channel edge that are intentionally left unused to form a “guard band” or (“frequency gap”) between the channel and adjacent channels. Under IEEE 802.11a/g, the two channels

("CH 2"and "CH 3" depicted above) collectively include 96 data subcarriers (and 8 pilot subcarriers).

27. The '326 Patent states that "[a]n embodiment of the present invention increases the data rate using channel bonding with OFDM using two or more channels at once." Ex.1001, 5:3-5. Fig. 19 graphically illustrates the concept of channel bonding (or "dual channel"), and is reproduced below.

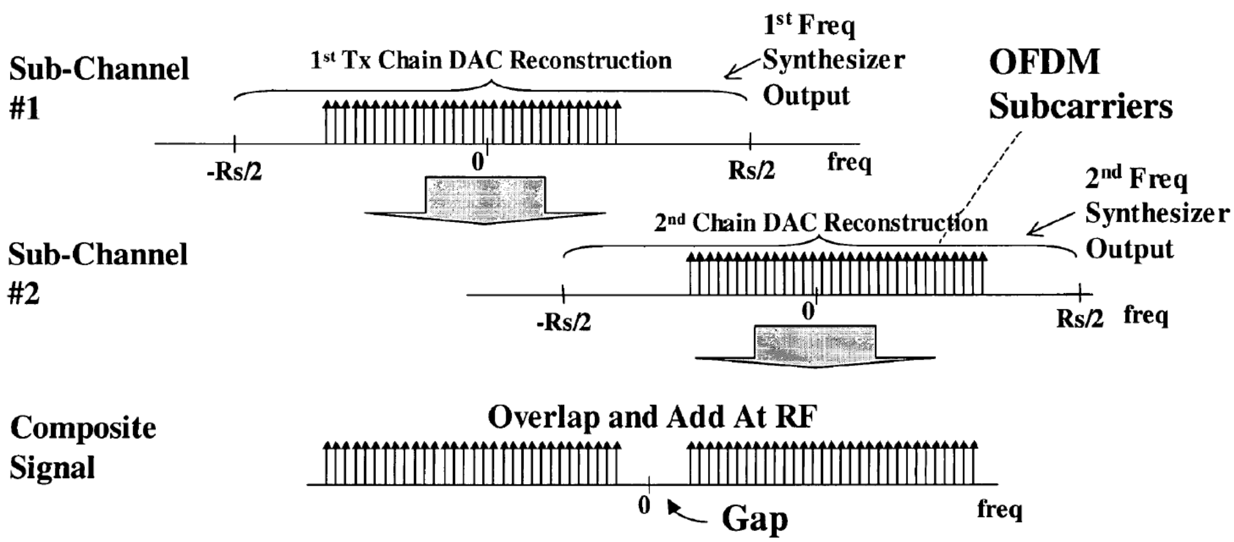


FIGURE 19

Ex.1001, Fig. 19. The top channel illustration ("Sub-Channel #1") depicts a first channel with subcarriers (the upward arrows) distributed relative to that channel's center frequency ("0"). The middle channel illustration ("Sub-Channel #2") depicts a second channel with subcarriers also distributed relative to the respective channel's center frequency. The middle channel illustration ("Composite Signal") depicts a combination of the first and second channels. Note the frequency "Gap" at the center, which corresponds to a guard band between the first and second channel.

28. The '326 Patent also states that "[a]nother aspect of the invention provides a technique for "filling the gap" between two signals with extra OFDM subcarriers." Ex.1001, 5:5-7. Fig. 20 graphically illustrates the concept of channel bonding with gap filling, and is reproduced below.

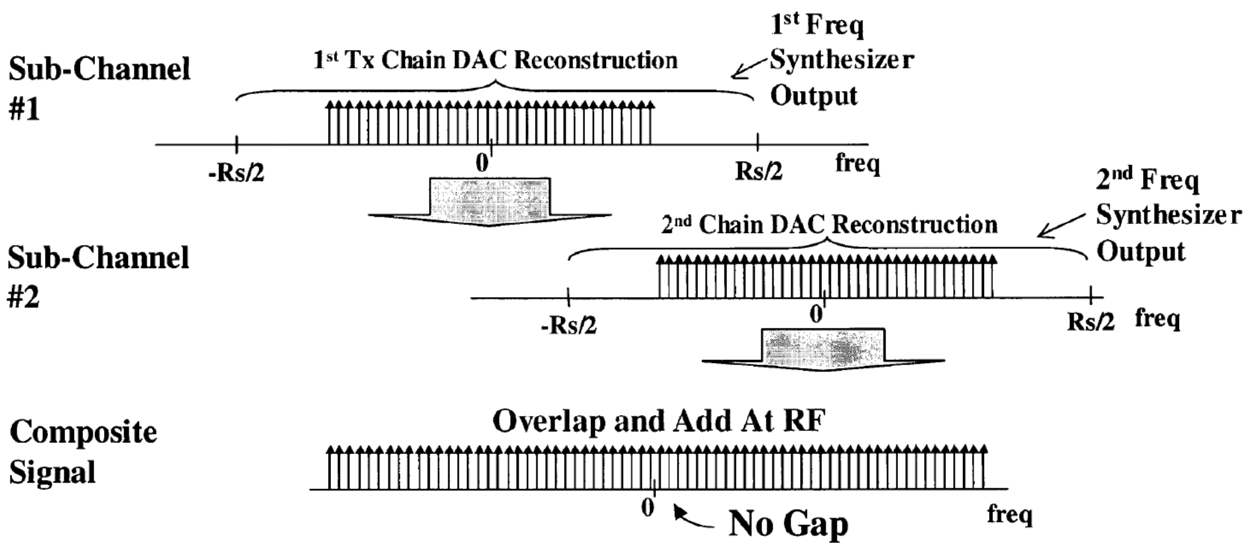
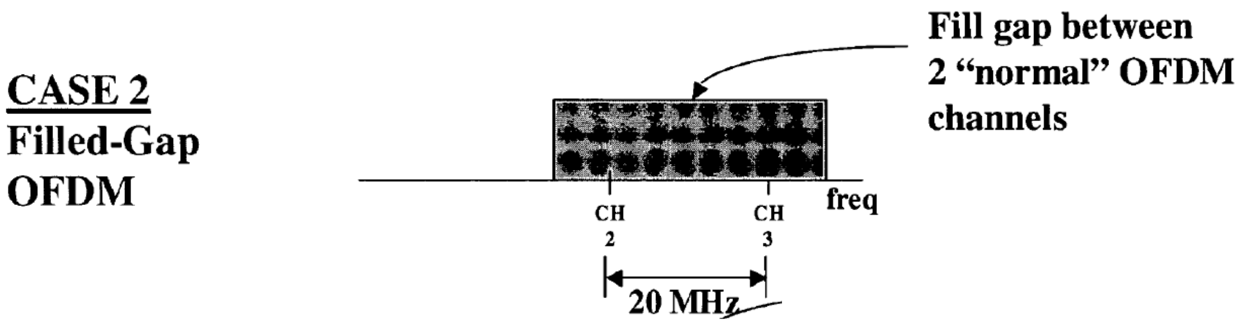


FIGURE 20

Ex.1001, Fig. 20. Note that the guard band (frequency gap) in Fig. 19 has been filled with subcarriers in Fig. 20. However, guard band regions outside the combined channels remain. An alternative view of gap filling is presented in Fig. 4 of the '326 Patent, the relative portion of which is reproduced below.



Ex.1001, Fig. 4 ("Case 2").

29. The '326 Patent further discloses an "all gaps filled" (Ex. 1001, 10:45) embodiment, in which the guard band regions to the left and right of the combined channels are filled with subcarriers, as well as the guard band between the two adjacent channels. Fig. 21 graphically illustrates the concept of channel bonding with all gaps filled, and is reproduced below.

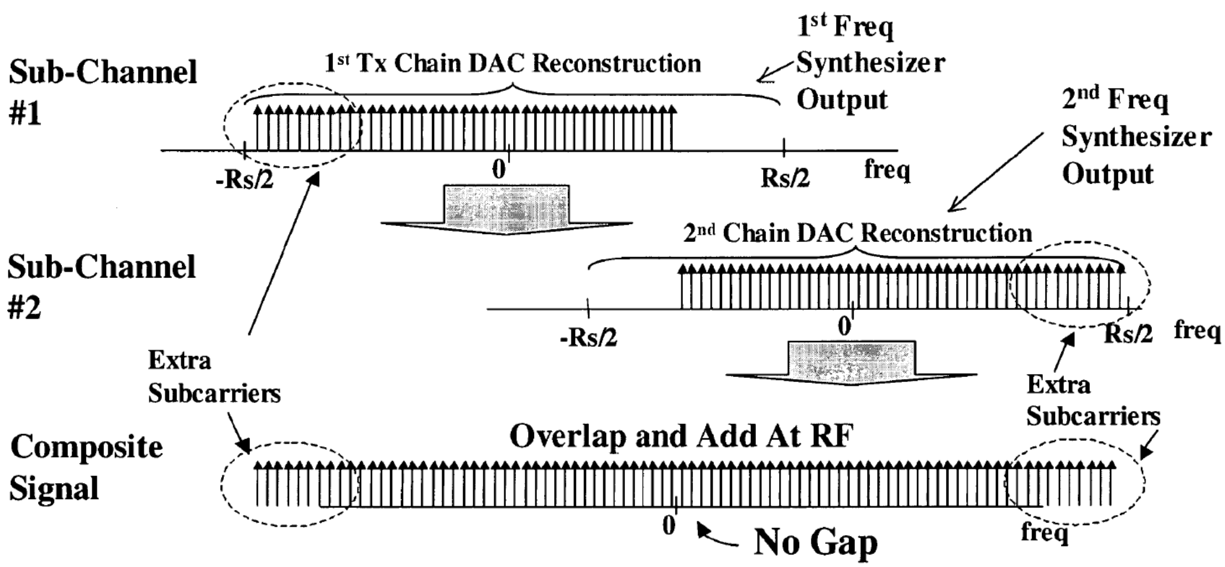
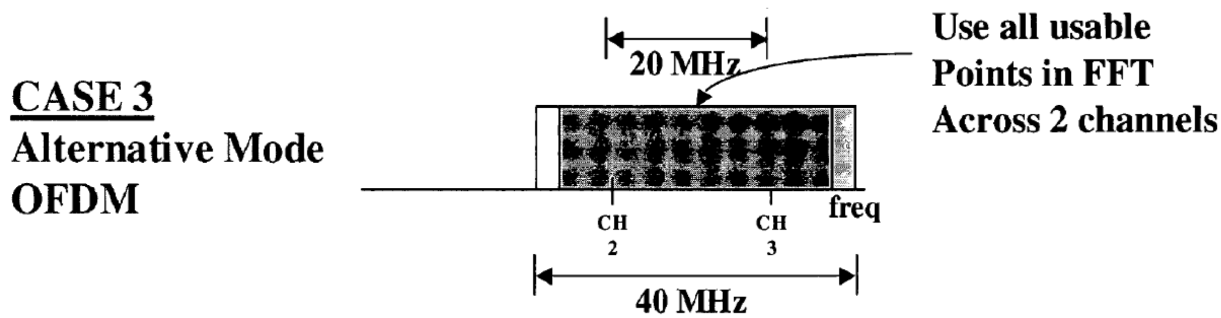


FIGURE 21

Ex.1001, Fig. 21. Note that the guard band (frequency gap) in Fig. 19 has been filled with subcarriers in Fig. 21, and "Extra Subcarriers" have also been added the left and right of the combined channels (with what were previously guard band regions). An alternative view of "all gaps filled" embodiment is presented in Fig. 4 of the '326 Patent, the relative portion of which is reproduced below.



Ex.1001, Fig. 4 ("Case 3"). Fig. 5 of the '326 Patent also illustrates channel bonding with gap filling and with "all gaps filled," and is reproduced below.

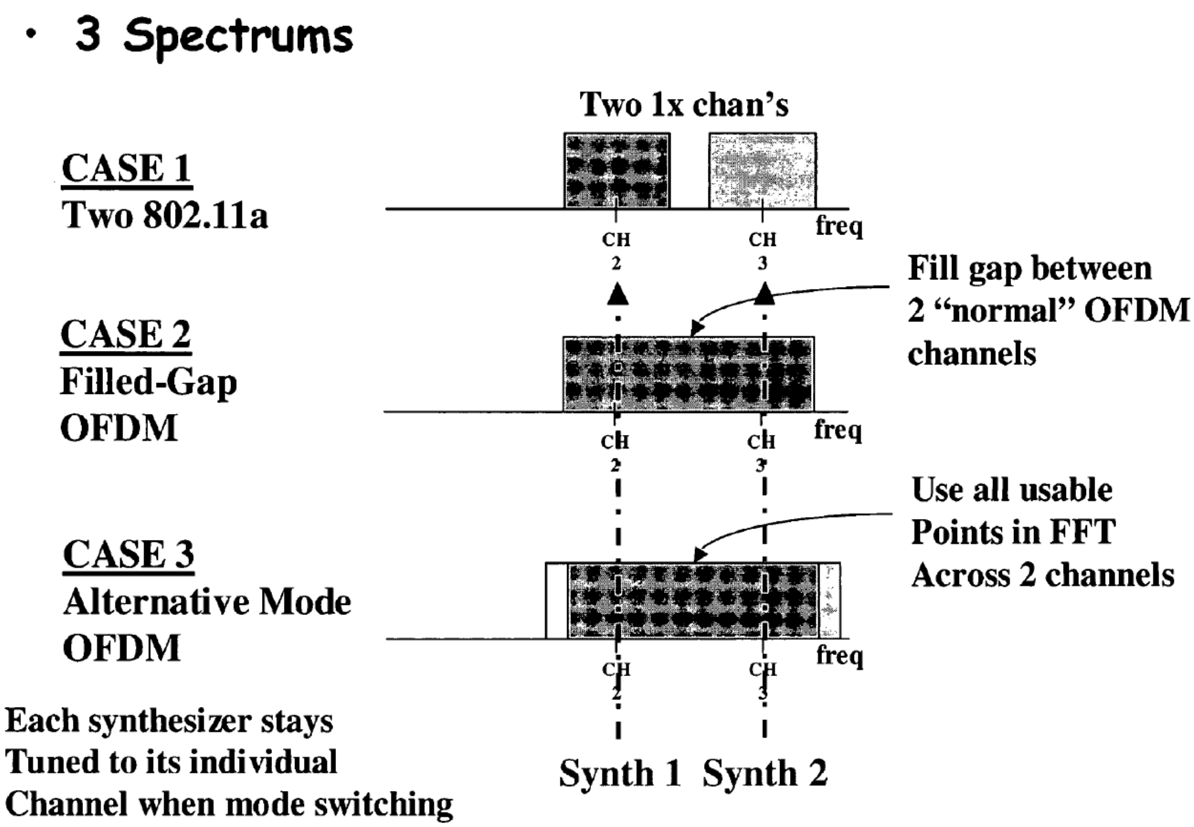


FIGURE 5

Ex.1001, Fig. 5. Fig. 5 notes that "[e]ach synthesizer stays [t]uned to its individual [c]hannel during mode switching." The '326 Patent contemplates switching between "legacy" signals (the individual channels CH2 and CH3 used separately, as depicted at the top of Fig. 5) and "wide" signals (the channel bonded and filled gap signal in center of Fig. 5).

30. The individual channels CH2 and CH3 at the top of Fig. 5 include 48 data subcarriers each, for a total of 96 data subcarriers when the two channels are channel bonded without gap filling. With both channel bonding and gap filling, 108 data

subcarriers are available. With channel bonding with "all gaps filled," 120 data subcarriers. Ex.1001, 10:31-36, 10:43-47.

31. The '326 Patent uses OFDM on the data subcarriers. Ex.1001, 5:3-15, Fig. 20, Fig. 21, Fig. 23, 8:28-33, etc. The '326 Patent also suggests using MIMO. Ex.1001, 12:53-58, Fig. 14. Fig. 14 is reproduced below.

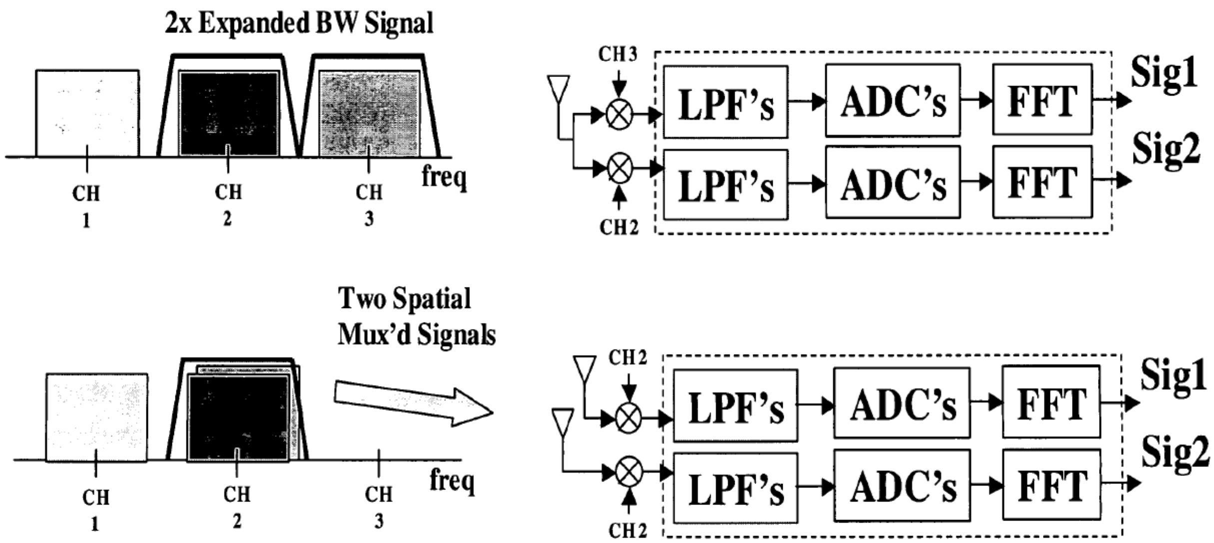


FIGURE 14

32. The '326 Patent uses a filter to combat aliasing. Ex.1001, 14:43-52. The '326 Patent describes its anti-aliasing as anti-aliasing as adaptive anti-aliasing function in the receiver. Ex.1001, 4:22-24. The goal of this adaptive anti-aliasing is to eliminate signal aliasing (sampling rate artifacts) due to adjacent channel waveform effects. Ex.1001, 3:63-66.

3. Overview of the Prosecution History of the '326 patent

33. During prosecution the examiner rejected the claims of the application that issued as the '326 patent many times over several pieces of prior art. Those rejections may be found at (Ex.1002, 311-320 (non-final rejection), 283-293 (final rejection), 212-225 (non-final rejection), 176-187 (non-final rejection), 119-137 (final rejection), 54-70 (non-final rejection)).

34. Applicant amended the then-pending independent method claim 1 of the '326 patent in response to the first, non-final rejection to recite: "filling a gap between the first channel and the second channel with a subcarrier."Ex.1002, 296. The examiner, however, did not deem this amendment sufficient to overcome the prior art, and maintained the rejection.

35. Applicant amended the then-pending claim 1 of the '326 patent to recite: "selecting at least a first channel and a second channel, the first and second channels being adjacent and each have a plurality of data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and second channels" and "filling [[a]] the frequency gap between the first channel and the second channel with a ~~subcarrier~~ plurality of data subcarriers."Ex.1002, 237. Applicant also added another method claim, which eventually issued as claim 16. Ex.1002, 239. The examiner did not deem the

amendment sufficient to overcome the prior art, and maintained the rejection with a secondary reference.

36. Applicant amended the then-pending independent claims of the '326 patent to recite: "the first and second channels being adjacent without any other channels therebetween and each have a plurality of data subcarriers," and "partially filling the frequency gap."Ex.1002, 195, 197. The examiner did not deem the amendment sufficient to overcome the prior art, and maintained the rejection with a different secondary reference.

37. Applicant amended the then-pending independent claim 1 of the '326 patent to recite: "partially filling the frequency gap between the first channel and the second channel ~~with a plurality of~~ by adding one or more data subcarriers into the frequency gap."Ex.1002, 237. The examiner did not deem the amendment sufficient to overcome the prior art, and maintained the same rejection.

38. Applicant amended the then-pending independent claim 1 of the '326 patent to recite: "selecting at least a first channel and a second channel, wherein the first channel and the second channel are adjacent without any other channels therebetween, wherein the first channel and the second channel [[and]] each have a plurality ~~having a number~~ of data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and

second channels," and "transmitting data subcarriers occupying the first channel, [[and]] the second channel, and the frequency gap in parallel to a receiver."Ex.1002, 80. Applicant also converted the second independent method claim into an apparatus claim by adding "means for" before each recited step. Ex.1002, 83. The examiner did not deem the amendment sufficient to overcome the prior art, and maintained the rejection with a third secondary reference.

39. Applicant amended the then-pending independent claims of the '326 patent to recite: "partially filling the frequency gap between the first channel and the second channel by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers."Ex.1002, 39, 41. Applicant also added a computer program product claim having scope commensurate with the pending apparatus claim. Ex.1002, 42.

40. The examiner subsequently allowed the application.

41. In the Notice of Allowance, the Examiner made the following Examiner's Amendment to each of the independent claims: "partially filling the frequency gap between the first channel and the second channel by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers using full

spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform." Ex.1002, 31.

42. The examiner did not make an explicit statement of reasons for allowance.

4. Claim Construction

43. I understand that claim terms reciting function without sufficient structure for performing that function are interpreted under a specific statutory framework[1]. The framework requires an analysis of the corresponding structure described in the specification as performing the claimed function. I find that certain terms of the '722 Patent's claims (identified below) should be interpreted using this framework. No express construction of the other challenged claims is necessary in this proceeding because the prior art renders these claims obvious under any reasonable construction.

44. From a perspective of a POSITA, "means" and "instructions" are each a nonce word. Here, claims 16 and 18 respectively recite "means for" performing and "instructions to" perform certain functions without identifying the structure that performs those functions. As shown below, the '326 Patent's specification identifies the structural components corresponding to the recited functions in these claims.

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[1] I have been informed that this legal standard is met when claim terms, viewed from the perspective of a POSITA: (A) lack meaning as the name for structure; and (B) are not defined in terms of structure by the remaining portions of the claim.

Claims	Function	Structure in '326 Specification
16.1 18.1	"selecting at least a first channel and a second channel" "select at least a first channel and a second channel"	The specification of the '326 patent does not link any specific structure to "selecting" channels. For example, no multiplexer or similar structure is depicted or described as routing or controllable "selecting" channels. Instead, the various dual-chain radios of Figs. 7, 16-18, 27, 30, 33, 43, 47, and 49 and the alternative single chain radios of Fig. 8 are shown as merely receiving (pre-selected) channels CH2 and CH3. Therefore a POSITA would understand the structure in the specification of the '326 patent that corresponds to the function "selecting at least a first channel and a second channel" to be a signal processing chain receiving two channels, and a POSITA would understand the "instructions" contemplated by the '326 patent that "select at least a first channel and a second channel" to be a signal processing chain receiving two channels and having at least one programmable element relating to processing two channels.
16.2 18.2	"partially filling the frequency gap with at least one additional subcarrier … using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform" "partially fill the frequency gap between the first channel and the	The specification of the '326 patent does not link any specific structure to "filling the frequency gap" (guard band) between adjacent channels with "data subcarrier[s]." Instead, the subcarriers for the guard band(s) are merely described as being used for data. For example the '326 patent describes using "2 times 48 data subcarriers (sc)=96 data sc" for "[d]ual-channel … without gap fill." 10:29-31), "64(left channel)+64(right channel)-6(left guard)−5(right guard)−4(pilot tones) −5(lost to DC offsets)=108 data subcarriers)" "using the OFDM filled-gap technique." 10:31-36), and "64+64−4−4=120 data subcarriers" for "dual

Claims	Function	Structure in '326 Specification
	second channel by adding one or more data subcarriers into the frequency gap… using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform"	channel with all gaps filled." 10:45-48). Therefore a POSITA would understand the structure in the specification of the '326 patent that corresponds to the function "filling the frequency gap with" "data subcarrier[s]" to be at least one IFFT calculator receiving data on subcarriers between two channels that correspond to a guard band region between the channels, and a POSITA would understand the "instructions" contemplated by the '326 patent that "fill the frequency gap with" "data subcarrier[s]" to be at least one IFFT calculator that can be programmed to receive data on subcarriers between two channels that correspond to a guard band region between the channels.
16.3 18.3	"combining the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)" "combine the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)"	The specification of the '326 patent does not link any specific structure to "combining" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)." Instead, the various dual-chain radios of Figs. 7, 16-18, 27, 30, 33, 43, 47, and 49 are merely shown and described as performing "2-64 point [I]FFTs that process two halves of the signal (1-upper and 1-lower)"concurrently on CH2 and CH3 (11:23-26), and the alternative single chain radios of Fig. 8 are shown and described as "using a single circuit that processes the whole signal (1-128 point [I]FFT)"on both channels CH2 and CH3 (11:26-27). Therefore a POSITA would understand the structure in the specification of the '326 patent that corresponds to the function "combining" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)" to be one or more IFFT calculators

Claims	Function	Structure in '326 Specification
		generating OFDM symbols for two channels using all 64 subcarriers for each channel, and a POSITA would understand the "instructions" contemplated by the '326 patent that "combine the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)" to be one or more IFFT calculators that can be programmed to generate OFDM symbols for two channels using all 64 subcarriers for each channel.
16.4 18.4	"transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel" "transmit data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel"	The specification of the '326 patent depicts and describes various radios as having signal outputs and either none, one, or two antennas. For example, the dual-chain radio of Fig. 7 and the alternative single chain radios of Fig. 8 are each without any antenna, merely two signal outputs. The dual-chain radios of Figs. 16-17, 27 (top), 30, 33, 43, and 49 are shown with two signal outputs, an adder, and one antenna, while the dual-chain radios of Figs. 18, 27 (bottom), and 47 are shown with two signal outputs and two antennas. The specification of the '326 patent describes "sending or receiving upper/lower signals with separate antennae" or with "one antenna." 15:50-52). Therefore a POSITA would understand the structure in the specification of the '326 patent that corresponds to the function "transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel" to be two signal outputs suitable for coupling with one or more antennas, and a POSITA would understand the "instructions" contemplated by the '326 patent that "transmit the first plurality of subcarriers, the second plurality of

Claims	Function	Structure in '326 Specification
		subcarriers, and the at least one additional subcarrier in parallel" to be two signal outputs can be programmed for coupling with one or more antennas.

A POSITA would understand the structure(s) to be hardware or hardware and either firmware or software for the "means for" limitations, and programmable hardware for the "instructions to" limitations.

B. Gardner (Ex.1006)

45. U.S. Patent 7,418,050 ("Gardner") was issued/published August 26, 2008, and was filed February 26, 2003 as Application No. 376,347. Gardner describes "[v]arious options for IEEE 802.11a extensions that would support higher data rates." Ex.1006, 2:15-16. At least two of the options, channel bonding and MIMO, were generally known and used in the relevant art. A POSITA would understand those two technologies to be distinct but compatible, suitable for use either separately or together. Channel bonding increases bandwidth utilization for a single data stream by allocating multiple channels to that stream, while MIMO increases bandwidth by using multiple, parallel spatial transmission paths for one data stream (multiplexed for concurrently transmission on the parallel spatial transmission paths) or multiple data streams (transmitted concurrently on the parallel spatial transmission paths). In combination within IEEE 802.11 systems, OFDM symbols

for adjacent channels combined by channel bonding may be transmitted in parallel on parallel spatial transmission paths with MIMO.

46. "One option is to use multiple channels to transmit the data stream; for example, data could be multiplexed between two 54 Mbps streams occupying two contiguous 20 MHz channels to obtain a rate of 108 Mbps." Gardner, Ex.1006, 2:16-20. A POSITA would recognize that statement as describing channel bonding. "A third option is to use multiple input, multiple output (MIMO) systems to increase the data rate and the operating range without increasing bandwidth." Ex.1006, 2:49-51.

47. Another option described by Gardner is "us[ing] multiple input, multiple output (MIMO) systems to increase the data rate and the operating range without increasing bandwidth." Ex.1006, 2:4951. In MIMO, "a transmitter splits the data into multiple streams and sends each via a separate antenna" "so that each transmitted data stream has a distinctive vector signature." Ex.1006, 2:51-55.

48. In one specific embodiment (Ex.1006, Fig. 1A), Gardner describes a MIMO system in which "a non-degenerate MIMO transmitter 100 send[s] signals to a non-degenerate MIMO receiver 150" "via each of a plurality of antennas" (where "the number of antennas used is at least as many as the number of modulated data

streams"). Ex.1006, 5:57-65.[2] "Data provided to transmitter 100 is split into two streams by a splitter 105; a first stream is sent via antenna 110a, while the second stream is sent via antenna 110b." Ex.1006, 6:1-4. "Receiver 150 receives a first signal via antenna 160a and a second signal via antenna 160b. … Typically, the signals received by antennas 160a, 160b are expected to be different in some way. Receiver 150 includes an estimator unit 155 that decombines the two signals in order to estimate the transmitted data sequence. In the most general case, each receiver antenna receives signals from each transmitter antenna with each path between a given transmitter antenna and a given receiver antenna after being transformed by the channel characteristics associated with that pair." Ex.1006, 6:9-24.

49. Gardner describes OFDM under IEEE 802.11a (Ex.1006, 1:41-2:2), and describes MIMO as an option for extension of the standard "that would support higher data rates." Ex.1006, 2:15-16, 49-61.

50. Gardner also provides for a plurality of transmitters and receivers working in parallel via a plurality of channels. Ex.1006, 3:25-29. Gardner also implements a receiver for receiving a transmitted signal comprising a plurality of data streams transmitted in parallel via a channel. Ex.1006, 4:59-62.

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[2] Gardner states that "an 'antenna' refers generally to any apparatus for coupling a transmitter or receiver to a channel and is to be understood as including any associated components such as a standard radio-frequency (RF) chain." Ex.1006, 2:65-2:1.

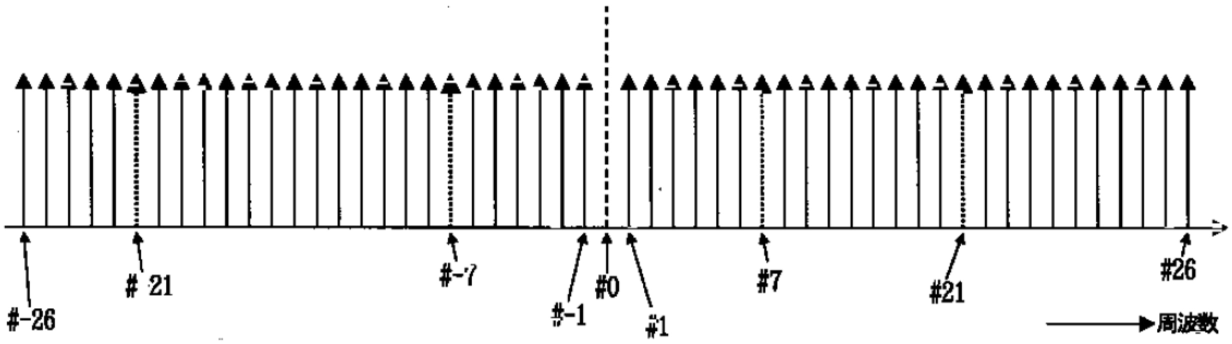
C. Mori (Ex.1007, Ex.1008)

51. Japanese Patent Application Publication No. JP2002319917A ("Mori") was published October 31, 2002. Mori is directed to generating and decoding a multicarrier signal. Ex.1008, [0001]. Mori references OFDM (Orthogonal Frequency Division Multiplexing) and QAM. Ex.1008, [0002], [0011]-[0013], [0018], [0020], [0021], [0026].

52. One goal of Mori is to limit wasted bandwidth: "Thus, to achieve higher transmission speeds within a limited bandwidth, it is important to eliminate waste in the use of the given frequency band and to effectively expand the practically usable bandwidth." Ex.1008, [0032]. Mori explicitly discloses multiple channels with specific frequency intervals "The practical wireless access system uses a bandwidth of 100 MHz in the 5 GHz band, with four channels spaced 20 MHz apart, and communication is conducted through each channel. FIG. 11 illustrates the channel arrangement used in the wireless access system." Ex.1008, [0003].

53. In Mori, each channel carries an OFDM symbol having 4 μs duration and includes 52 subcarriers (#1 to #26 and #−1 to #−26) with 312.5KHz spacing, defined relative to a center frequency (#0, used for DC), with four subcarriers (#−21, #−7, #7, #21) used for pilot signals and the remaining 48 subcarriers allocated for data:

【図１２】



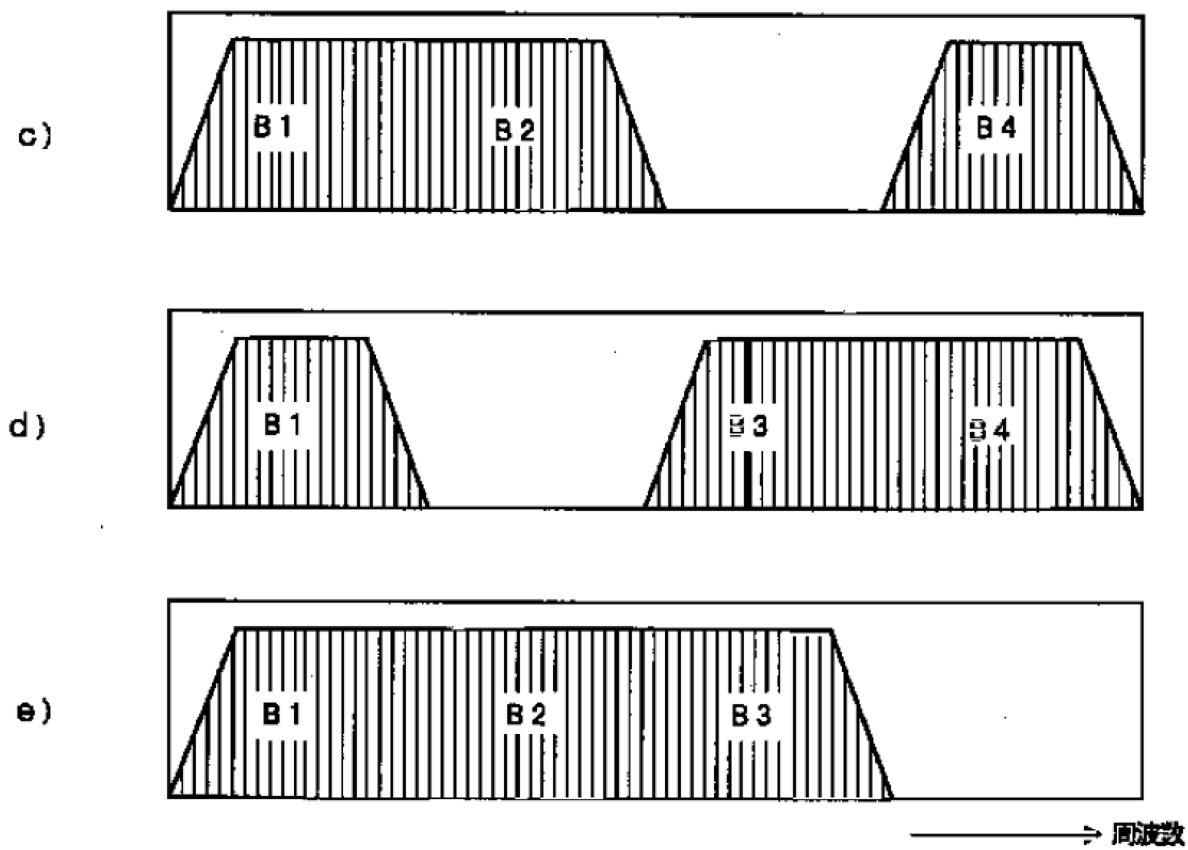
Ex.1007, Fig. 12; Ex.1008, [0005], [0009], [0110]. A POSITA would recognize the use of 4μs OFDM symbols in a channel structure of the type described in Mori as at least analogous to IEEE 802.11a/g (i.e., "802.11-like").

54. Mori is also focused in improved efficiency of transmissions: "The present invention has been made in view of the above points, aiming to enable high-speed, large-capacity transmission, flexibly and efficiently respond to a wide range of transmission speeds, and ***realize a transmission system with high channel utilization and frequency utilization efficiency*** through a generation method of multi-carrier signals, a decoding method of multi-carrier signals, and a configuration of devices for them." Ex.1008, [0036] (emphasis added).

55. Mori describes "communication bandwidths B1 to B8," among which "B3 … is already used by user A, and B6 and B7 are already used by user B, while user C is in a situation where communication is performed by … the remaining B1, B2, B4, B5, and B8 bandwidths." Ex.1008, [0074].

56. Mori depicts and describes channel bonding and gap filling using any two or more adjacent channels among four consecutive channels B1, B2, B3, and B4:

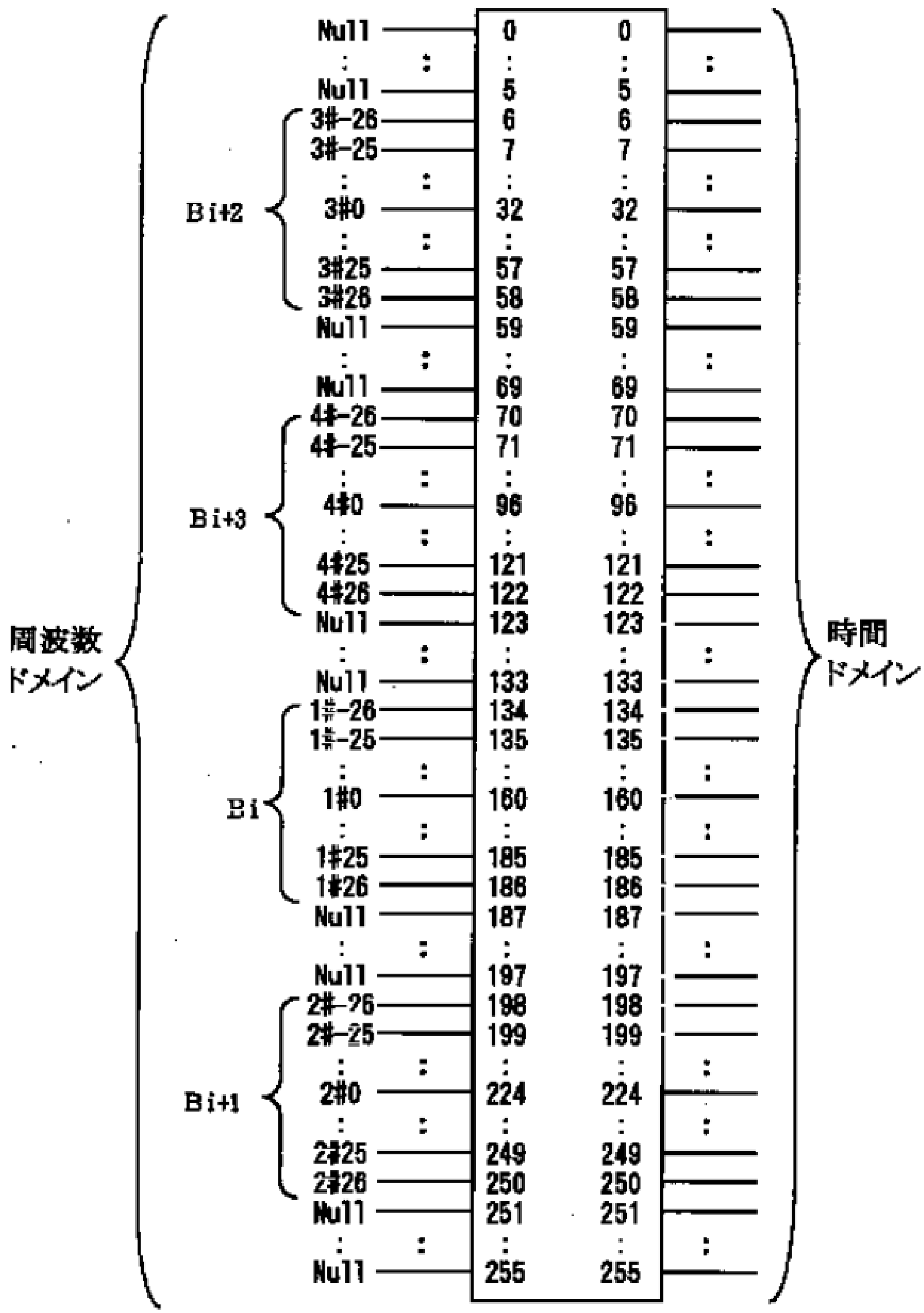
【図8】



Ex.1007, Fig. 8; Ex.1008, [0120], [0121], [0122]. Mori describes "the addition of 10 subcarriers in the guard band area" to "increase in transmission rate." Ex.1008, [0125].

57. Mori also depicts and describes "a 256-point IFFT processor performing 64-point IFFT operations simultaneously" on the four consecutive channels B1, B2, B3, and B4 (labeled "Bi", "Bi+1", "Bi+2", and "Bi+3"in Fig. 3):

【図３】


周波数ドメイン
時間ドメイン
Bi+2
Bi+3
Bi
Bi+1
Null
3#-26
3#-25
3#0
3#25
3#26
4#-26
4#-25
4#0
4#25
4#26
1#-26
1#-25
1#0
1#25
1#26
2#-26
2#-25
2#0
2#25
2#26
0
5
6
7
32
57
58
59
69
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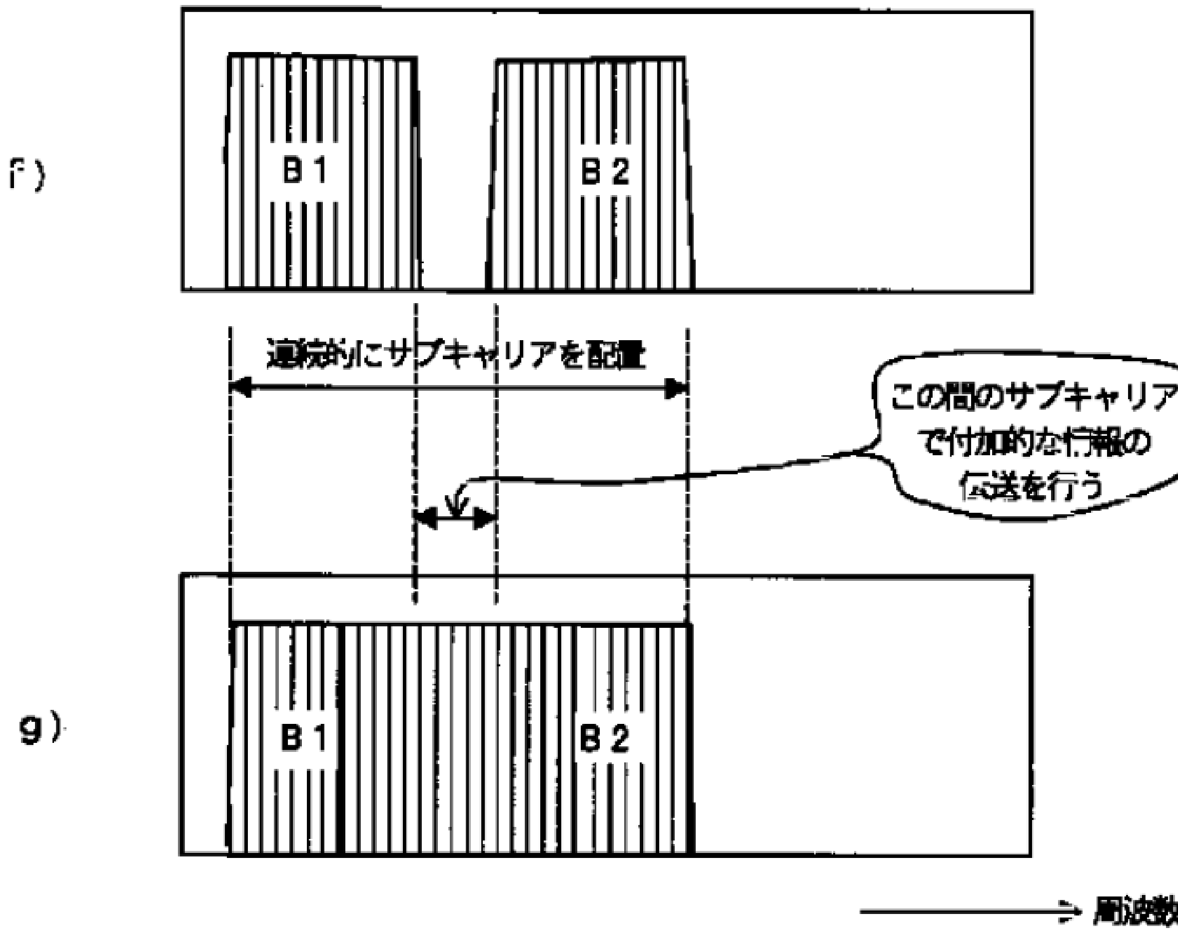
Ex.1007, Fig. 3; Ex.1008, [0066]. Mori describes the inputs labeled "#−26"to "#−1"and "#1"to "#26" for each of the four channels as data or pilot subcarriers, inputs labeled "#0" for each channel as used for DC, and inputs labeled "Null" are for a guard band, when used. Ex.1008, [0005], [0011], [0113], [0115].

58. Mori teaches that, by using the 256-point IFFT calculator of Fig. 3 to simultaneously perform 64-point IFFT operations on multiple channels, "there is no need to provide … guard bands" "because the OFDM signals of multiple bands generated by a single IFFT are orthogonal to each other, and thus do not interfere with one another." Ex. 1008, [0117]. "Even when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for the omission of guard bands." Ex. 1008, [0118].

59. In a specific example of channel bonding and gap filling between channels B1 and B2, Mori depicts and describes "the addition of 10 subcarriers in the guard band area" between those two channels:

【図9】



Ex.1007, Fig. 9; Ex.1008, [0125]. "[B]ecause subcarrier signals [being] inserted between bands B1 and B2 are generated, data allocation may be made for 10 subcarriers at 10 input terminals excluding input terminal 192 among input terminals 187 to 197." Mori, Ex.1008, [0124]. Input terminals 187 to 197 are labeled "Null" in Fig. 3 of Mori. A POSITA would recognize that as indicating the guard band between channels, when a guard band used.

D. Bolinth (Ex.1009)

60. U.S. Patent Application Publication No. 2005/0259628 ("Bolinth") was published November 24, 2005, and was filed July 7, 2003 as Application No. 525,606. One goal of Bolinth is the reduction or elimination of inter-channel interference. Ex.1009, [0013], [0016]. Bolinth uses known technologies such as OFDM, guard bands, and subcarriers. Ex.1009, Fig. 3a, [0014]-[0016], [0024], [0028] [0037], claim 5, claim 7, claim 15.

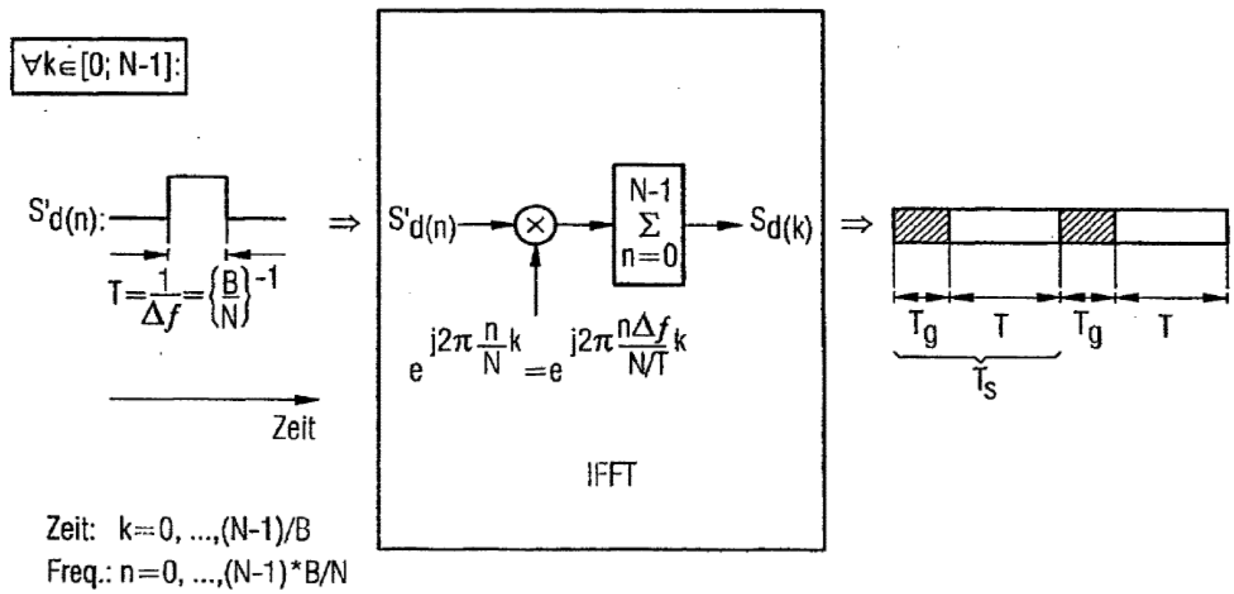
61. Bolinth acknowledges that, in "Orthogonal Frequency Division Multiplexing OFDM … functioning in accordance with the IEEE 802.11 Standard … which simultaneously [employs] a number of carrier frequencies … for the transmission of a digital signal," "these carrier frequencies are only modulated with a reduced transmission rate in relation to the overall transmission rate available (across all carriers)." Ex.1009, [0001].

62. Bolinth attributes the "reduced transmission rate" to the guard region added to each OFDM symbol "According to the prior art, each symbol pulse $S_{d(k)}$ of a kth carrier f_k for N sub-carriers of a symbol carrier band of the bandwidth B is modulated; i.e., for each symbol pulse $S_{d(k)}$ for a time window of length T an Inverse Fast Fourier Transformation (IFFT) in accordance with the formula

$$S_{d(k)} = \sum_{n=0}^{N-1} S_{d(n)} e^{j2\pi\frac{n}{N}k}$$

is applied and from it an OFDM symbol $S_{d(k)}$ is generated. To counteract echoes and/or synchronization errors, this OFDM symbol $S_{d(k)}$ with duration T, through which the window length of a corresponding Fourier analysis in the receiver is also provided with a guard time (i.e., the time T will be extended by a time T_g) usually referred to as the guard time so that overall for the OFDM symbol to be sent $S_{d(k)}$ a symbol time T_s is produced." Ex.1009, [0023]. Bolinth illustrates the impact of adding guard time T_g to OFDM symbol duration T on total symbol time T_s:

FIG 1A Prior art



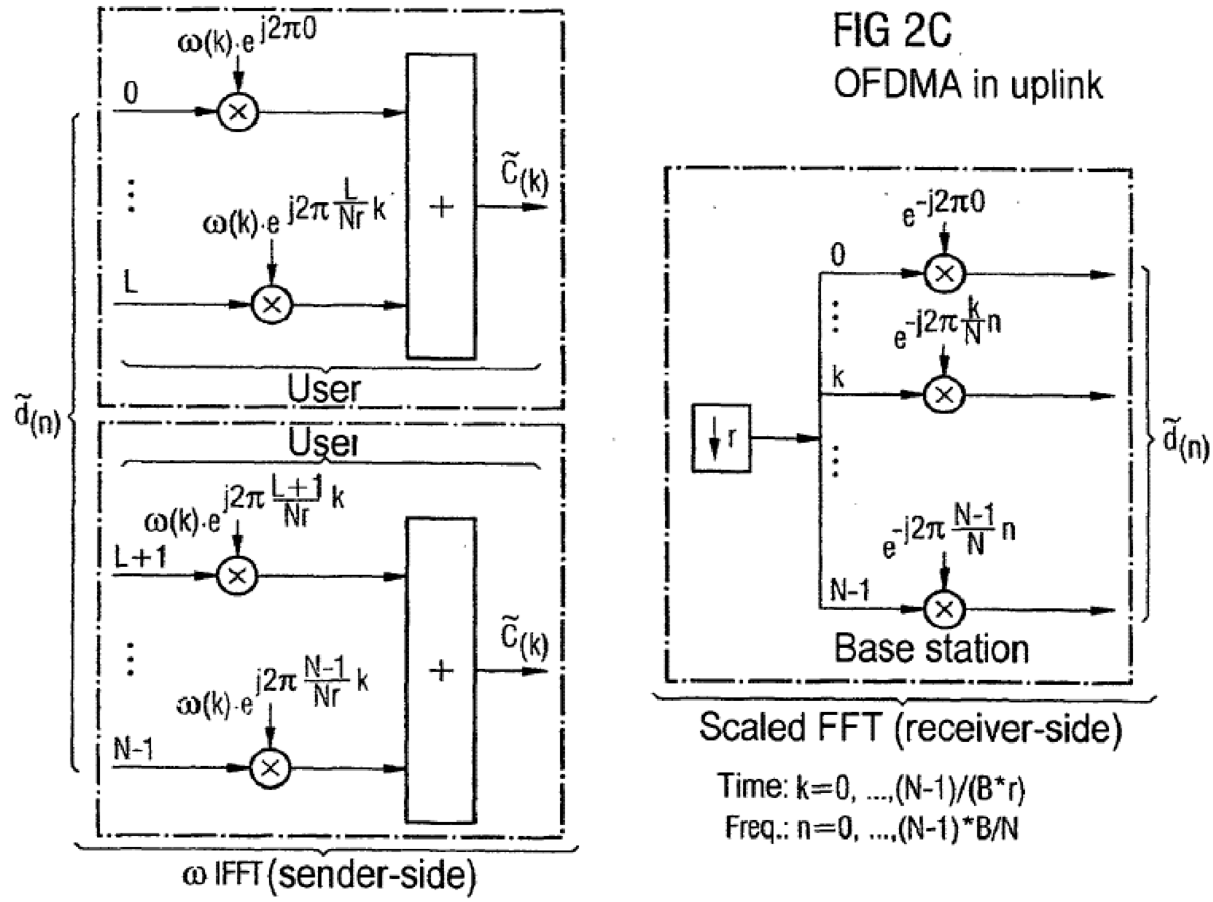
Ex.1009, Fig. 1A.

63. Bolinth teaches that the guard region exists because "sub-carriers in edge areas of a sub-carrier band are not modulated, in order to eliminate interference on adjoining frequency slots." Ex.1009, [0009]. Bolinth observes that inter-channel

interference in the form of "crosstalk effects between the carriers" for "a number of users (Multiple User system)" (Ex.1009, [0003]) may result in part from either or both of "doppler shift arising from the movement of mobile terminals" or "oscillator phase noise" (Ex.1009, [0005]). Specifically, Bolinth observes, in multi-user systems "the doppler shifts [are not] constant over all sub-carriers as a result of the different relative speeds of the mobile subscribers," while "the phase noise … is uncorrelated as a rule since it is predominantly generated by the unsynchronized oscillators of the individual users." Ex.1009, [0010].

64. Bolinth is therefore focused on improving data rate by employing subcarriers within the guard band with suitable filtering: "Filtering the sub-carriers in the edge area of an OFDM symbol also allows the guard band (i.e., the number of the unused sub-carriers at the edge of the OFDM symbol) to be reduced so that, in addition, a comparatively higher data rate can be achieved." Ex.1009, [0014]. A POSITA would understand the description of reducing the number of "unused" subcarriers in the guard band in order to achieve a higher data rate to indicate that some of the guard band subcarriers are used to carry data.

65. The filtering in Bolinth is implemented within parallel IFFTs performed concurrently on two adjacent channels, illustrated by Fig. 2C (which is reproduced below).



Ex.1009, Fig. 2C. Bolinth describes the IFFT (sender side) of Fig. 2C as "an inventive OFDMA structure in the uplink, with 2 different users (namely, User A and User B) using different sub-carrier frequency bands." Ex.1009, [0037]. A POSITA would understand the IFFT on subcarriers 0 through L for User A, performed concurrently with the IFFT on subcarriers L+1 through N−1 for User B, obviates the need for bandwidth switching.

66. In Bolinth, "pre-emphasis is applied in order to suppress the ICI" on "adjacent sub-carrier L of the first user (User A) and … sub-carrier (L+1) of the second user

(User B)." Ex.1009, [0037]. Specifically, "with the exception of those carriers … located in the edge area of the sub-carrier band, all symbol pulses … assigned on the remaining carriers … are fed to the IFFT in accordance with the prior art, whereas the symbol pulses on the carriers … in the edge area of the sub-carrier band … are subjected to an oversampling with the rate r and pre-emphasis, with the pre-emphasis being undertaken such that the relevant symbol pulse … is windowed or filtered with a pre-emphasis function … [that] determines the frequency response of the pre-distorted/filtered sub-carrier." Ex.1009, [0028]. A POSITA would therefore understand Bolinth to describe performing concurrent IFFTs on adjacent channels with oversampling and filtering of guard bands subcarriers on the channel edges.

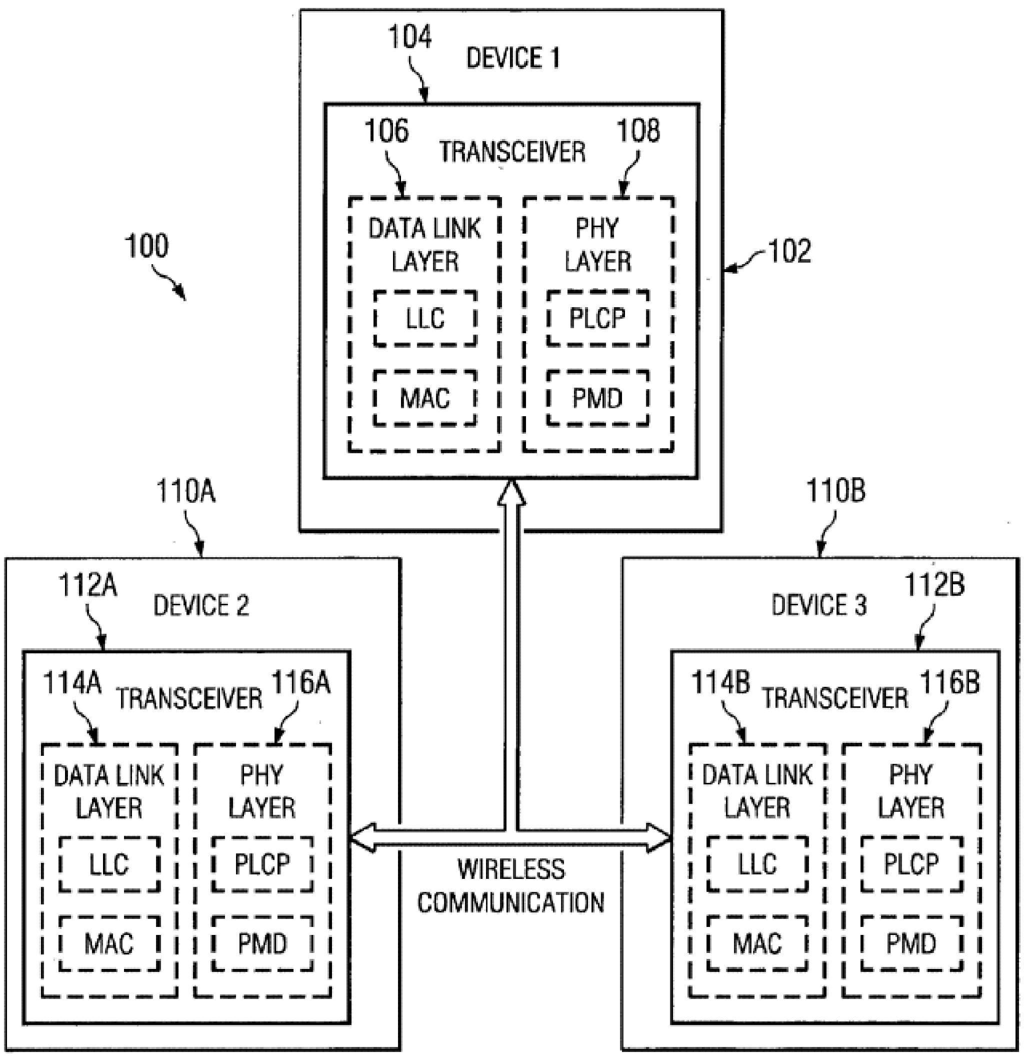
E. Lu (Ex.1009)

67. U.S. Patent Application Publication No. 2005/0138194 ("Lu") was published January 23, 2005, and was filed December 23, 2003 as Application No. 744,864. Lu is directed towards multi-protocol communication. Lu includes embodiments that are wireless and use at least two protocols, such as "a first wireless protocol (e.g., 802.11a, 802.11g)"and "a second wireless protocol (e.g., 802.11n)." Ex.1010, [0015]. Lu addresses interoperability of higher data transfer rate devices under the proposed IEEE 802.11n and lower data transfer rate devices under IEEE 802.11a/g. For example, "As will be described herein, embodiments of the invention may comprise a wireless system, wherein at least one device of the system uses a first

protocol and at least one device of the system uses a second protocol. In at least some embodiments, the devices that use the first protocol may communicate with each other using a different (e.g., lower) data transfer rate than the devices that communicate using the second protocol." Ex.1010, [0026].

68. Figure 1 shows a wireless embodiment of Lu:

FIG. 1



69. Lu utilizes OFDM and QAM. Ex.1010, Fig. 3, [0016] (including Table 1), [0017] (including Table 2), [0024], [0025] (including Table 3), [0029], [0037]. While Lu does not explicitly disclose FFTs/IFFTs, Fourier transforms and inverse Fourier transforms are employed for the frequency domain to time domain (inverse Fourier transform) conversions and time domain to frequency domain (Fourier transform) conversions involved in OFDM. FFTs and IFFTs are practical implementations of Fourier transforms and inverse Fourier transforms, respectively. Thus a POSITA would understand that the use of OFDM by Lu also means, for practical purposes, that FFTs/IFFTs are likely also used by Lu.

70. Lu also discloses a goal of improving data transfer rates: "While existing wireless standards allow electronic devices to communicate, it is desirable to increase the data transfer rate between electronic devices to provide improved performance and capabilities to wireless systems. Unfortunately, pre-existing wireless standards may limit the data transfer rate between devices." Ex.1010, [0001].

71. For higher data transfer rate devices operating under the proposed IEEE 802.11n, Lu describes "RATE2 field bits (B4-B0) [that] may be defined as": a "bit 'B4' [that] may be a MIMO (Multiple Input Multiple Output) indication bit, wherein

a '0' value indicates STTD (Space-Time Transmit Diversity)[3] and a '1' value indicates VLST (Vertical Layered Space Time)[4] diversity"; a "bit 'B3' [that] may be defined as a channel bonding indicator bit, wherein a '1' value indicates that a channel bonding mechanism is used. For example, one such channel bonding mechanism may simultaneously transmit data frames over two adjacent channels as if it were a single channel with twice the bandwidth"; and a "bit 'B2' [that] may be defined as a shortened guard interval indicator bit, wherein a '1' value indicates a shortened guard interval has been used (e.g., the interval guard may be shortened from 800 ns to 400 ns when a data rate of 140 Mbps is used)." Ex.1010, [0026]. A POSITA would recognize that the channel bonding indicator bit and the shortened guard interval indicator bit could be used independently and in combination, such that both channel bonding and a shortened guard region could be concurrently implemented. A POSITA would understand the description of a shortened guard interval, when associated with description of a higher data rate (140 Mbps versus 96 Mbps) while

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[3] "Space-Time Transmit Diversity" is a multiple input, single output (MISO) technique that involves transmitting time-delayed replicas of the same data stream from multiple antennas to a single receiver antenna, to improve signal-to-noise ratio (SNR) and enhance reliability in environments exhibiting channel fading.

[4] Also known as "Vertical Bell Labs Layered Space-Time" (V-BLAST), "Vertical Layered Space Time" is a MIMO technique using multiple antennas at both the transmitter and the receiver to increase data transmission capacity as well as reliability.

using the same 20MHz channels with 312.5KHz spaced subcarriers as in 802.11, indicates that a portion of the guard interval is used to carry data

F. Williams (Ex.1011)

72. U.S. Patent Application Publication No. 2003/0048462 ("Williams") was published March 13, 2003, and was filed September 6, 2001 as Application No. 947,735. Williams observes that an "OFMD[transmitter modem] encodes data symbols in the frequency domain and then uses an inverse Fourier Transform to convert the frequency domain symbol into its time domain representation for transmission purposes," while "[a]t a receiving end …, another modem receives the time domain symbol and performs a Fourier Transform to return the time domain symbol back to its frequency domain representation, which permits recovery of the encoded data." Ex.1011, [0003]. "The frequency domain symbol consists of a set of points from individual signal constellations that are simultaneously presented to the inverse Fourier Transform. The inverse Fourier Transform effectively modulates each constellation point with a unique, but related, frequency and then sums the resulting time domain waveforms to form a single time domain waveform that contains the original information. The inverse Fourier Transform has a fundamental frequency, and each unique frequency is an integer multiple of this fundamental frequency. Similarly, at the receiving end, the Fourier Transform effectively splits the time domain waveform into components that are carried by the unique, but

related, frequencies and then demodulates each one to obtain the constellation point that was transmitted." Ex.1011, [0004].

73. Due to "[r]eal-world effects such as multipath delays and inter-carrier crosstalk," "when a … signal from one symbol appears on another symbol, discontinuities are introduced … known as inter-symbol interference (ISI)," which "can introduce errors into the signal stream, which in turn results in a reduction of the overall data transfer rate of the communications system." Ex.1011, [0006]. "Multipath delays occur when wireless signals are reflected off objects (such as buildings and walls) and arrive at different times at the destination." Ex.1011, [0005].

74. "In an attempt to combat ISI, guard bands are inserted periodically within the signal stream. The guard bands contain … unused data … inserted into the signal stream to help mitigate the effects of ISI. The guard bands themselves can be a significant portion of the overall signal stream. In the IEEE 802.11a technical standard, guard bands account for 20% of the total signal stream." Ex.1011, [0007].

75. According to Williams, an alternative to "null" or unused subcarriers is that "[t]he guard bands [may] contain repeated data … or a specified signal sequence that is inserted into the signal stream." Ex.1011, [0007]. "The generation of the guard bands that contain repeated data uses a relatively simple procedure known as cyclic extension, wherein" "the modem takes a portion of the data stream … and replicates

a percentage of the data at one end of the portion and places that percentage at the other end of the portion." Ex.1011, [0008]. "The actual percentage replicated for guard band purposes depends upon the communications system in question, the IEEE 802.11a technical standard specifies 25%," such that "25% of the information at one end of the unit is replicated at the other end." Ex.1011, [0008]. Williams thus describes gap filling, with 25% of the transmitted data repeated in the guard band.

76. Williams observes that, "[a]ccording to the IEEE 802.11a technical standard, the guard band … occupies one-fifth (20%) of the transmission unit … while the … data occupies the remaining four-fifths (80%)." Ex. 1011, [0043]. As a specific example of how "the guard band … contains the same data as the fourth segment," Williams describes the data as being represented by "'A B C D'," and depicts and describes "duplicating the 'D' and placing at the end of the input stream" to "produce[as an] output a sequence of letters, 'D A B C D'." Ex. 1011, [0046], see also Figs. 3-4. A POSITA would understand that comparing the repeated data "D" in the guard band to the last segment can be used to detect and correct errors in the last segment.

77. A POSITA would recognize that the repeated data may be used for error correction, potentially increasing data rates by avoiding the need for retransmission of OFDM symbols distorted during transmission. A POSITA would further understand that repeating a predetermined portion of the OFDM symbol obviates

one need for a guard band, since checking for the repeated data may be used to detect edges of the OFDM symbol.

G. General Knowledge

78. In this section, I provide an overview of the background of the art as understood by a POSITA during the relevant timeframe. There are general terms that would be well known by a POSITA which are used in both the '326 patent and in Gardner, Mori, Bolinth, Lu, and Williams. Those terms are briefly described here.

1. Channel

79. A POSITA would understand a channel to be a frequency band (or range of specific frequencies) that includes a number of subcarriers (specific frequencies) allocated to convey signals carrying information between a transmitter and a receiver.

80. The term channel often implicates frequency division multiplexing (FDM). FDM divides the total available bandwidth of a communication band into non-overlapping frequency bands (channels, or "sub-bands"), each carrying a separate signal. All signals are transmitted in parallel and at the same time, but occupy different frequency ranges and therefore do not interfere with each other.

81. In IEEE 802.11 (a/k/a "WiFi") systems, regardless of which 802.11 wireless standard relevant to the '326 Patent is applied (802.11a/g, 802.11n, etc.), the center

frequencies for channels are separated by 20MHz. For example, one 20MHz channel might cover from 2.412GHz to 2.432GHz.

82. The 2.4GHz frequency band for IEEE 802.11 systems has 14 channels. In the United States, FCC regulation permits the use of only channels 1 – 11. The 5GHz frequency band uses 24 non-overlapping channels divided into different Unlicensed National Information Infrastructure (UNII) sections: UNII-1, UNII-2, UNII-2 extended, UNII-3, and ISM (Industrial, Scientific and Medical). Each section has its own recommended uses and restrictions.

2. Subcarrier

83. A POSITA would understand a subcarrier to be a specific frequency within a range of frequencies (channel). A channel typically includes a number of subcarriers.

84. In IEEE 802.11 systems, each 20MHz channel comprises equally spaced (in the frequency domain) subcarriers separated by 312.5KHz, or 64 subcarriers. Under IEEE 802.11a/g, the center frequency (subcarrier 0) in a channel is not used for data or pilot signal transmission. Instead, that subcarrier is a "null" subcarrier, typically used in determining the direct current (DC) offset of the remaining subcarriers. As discussed below, subcarriers on the edges of a channel are also often "null" subcarriers, forming guard bands at both edges and between adjacent channels.

85. Subcarriers within an IEEE 802.11 channel are numbered sequentially relative to subcarrier 0, with negative numbers (e.g., −7) indicating subcarriers at frequencies

below that of subcarrier 0 and positive numbers (e.g., +7) indicating subcarriers at frequencies above that of subcarrier zero. Subcarriers −20, −7, +7, and +26 are "pilot" subcarriers, each carrying a known signal used at the receiver for synchronization, channel estimation, and frequency offset correction.

3. Guard Band

86. A POSITA would understand a guard band (frequency domain) or guard "interval" (time domain) to a region in which no interfering signal is normally transmitted. A guard band may be one or more subcarriers, while a guard interval is a time period.

87. In IEEE 802.11 systems, the guard band are subcarriers between adjacent channels that typically are intentionally left unused, to avoid (or at least reduce) inter-symbol interference ("ISI") between the two channels. The unused subcarriers do not carry data (information) or pilot signals, and are sometimes referred to "null" subcarriers or signals. Because guard band subcarriers do not carry data, data rates/data throughput are affected.

4. Gap Filling ("filling the frequency gap")

88. A POSITA would understand "filling the frequency gap" between two channels to refer to using the subcarriers forming the guard band between adjacent channels to carry data (instead of "null" signals).

89. In the context of IEEE 802.11 systems, gap filling is one way to increase data rates, through guard band reduction by using (former) guard band subcarriers to carry data. If all subcarriers corresponding to a guard band between two channels are used to carry data, the "frequency gap" between those channels is "filled."

5. Channel Bonding

90. A POSITA would understand channel bonding as an access method in which two or more links ("channels") are combined to carry a single data stream. Channel bonding is performed for redundancy, fault tolerance, or increased throughput. Channel bonding can be used in wired or wireless networks, combining two or more channels into a single (effectively broader channel) to increase data throughput. By merging multiple channels, the system can carry more data for an individual data stream simultaneously, leading to faster downloads, smoother streaming, and better overall performance for that data stream.

91. In IEEE 802.11 systems, channel bonding is simply performed by allocating multiple channels for one transmission period to the same data stream being sent between a transmitter and a receiver, rather than to separate data streams (possibly intended for different receivers).

6. Orthogonal Frequency Division Multiplexing (OFDM)

92. A POSITA would understand OFDM to refer to a digital modulation technique (and a form of FDM) in which data is efficiently carried by multiple subcarriers within an OFDM "symbol."

93. OFDM was adopted for use in wireless local area networks under the 1999 IEEE 802.11a standard, originally in the 5GHz frequency band, and later extended in 2003 under IEEE 802.11g to the 2.4GHz band.

94. In OFDM, "a stream of data is transmitted over multiple small frequency sub-channels," with "multiple sub-carrier signals . . . incorporated within each OFDM symbol" using one of a number of known "modulation schemes [that] employ[] a corresponding constellation map with variable constellation points corresponding to a corresponding variable number of bits for achieving the various data rates." Ex.1001, 1:66-2:10.

95. Modulation schemes that are employed in IEEE 802.11 systems include Binary Phase Shift Keying (BPSK), Quadrature PSK (QPSK), and Quadrature Amplitude Modulation (QAM). Ex.1001, 2:3-15.

96. Phase shift keying (PSK), the base form of BPSK and QPSK, encodes data by modulating the phase of the carrier wave. A "phase" is a more complete description of a transmission than just frequency or amplitude. For two transmissions to be in

the same phase, they need to have the same wavelength (frequency) and cycle position. "Phase shifting" is the process of shifting to a different phase.

97. QAM is a modulation technique used in modern communication systems that combines amplitude and phase modulation to transmit data efficiently over a carrier signal, and is widely used in systems like Wi-Fi, cable modems, cellular networks (LTE and 5G), and digital television. QAM encodes data by varying both the amplitude (signal strength) and phase (angle of the carrier wave), by combining two carrier waves that are 90 degrees out of phase (hence the term "quadrature"). One wave is the in-phase component (I); the other is the quadrature component (Q).

98. In OFDM, the modulated signals are assigned to a set of subcarriers for a channel).

7. Synthesizer and Frequency Popping

99. A POSITA would understand a (frequency) synthesizer to be a device or circuit generating the subcarriers needed for transmitting an OFDM symbol on a channel.

100. A POSITA would understand frequency-popping to refer to the effects of a frequency synthesizer switching rapidly from a first center frequency to a second center frequency. These effects, which can result from non-ideal operation of local oscillators (LOs) and filters, are not unique to IEEE 802.11 systems or OFDM.

101. In IEEE 802.11 systems (among others), OFDM employs a set of frequency subcarriers (or "tones"). The tones are orthogonal sinusoids, allowing OFDM to simultaneously transmit data on multiple parallel subcarriers without significant interference. Preferably precise, stable frequencies for each subcarrier within the channel are needed for the transmitter and the receiver to communicate over that channel.

8. Fast Fourier Transform (FFT)/Inverse Fast Fourier Transform (IFFT)

102. A POSITA would understand FFT and IFFT to refer to computations performed to convert a set of time domain signals into frequency domain signals (FFT) or a set of frequency domain signals into time domain signals (IFFT).

103. In IEEE 802.11 systems, IFFTs are the most common way to convert a set of subcarriers for a channels into an OFDM symbol for transmission, and FFTs are the most common way to convert a received OFDM symbol into the time domain.

104. The Fourier Transform is a mathematical tool that transforms a function of time (or space) into a function of frequency, allowing analysis of complex signals by decomposition into individual frequency components. Essentially, the Fourier Transform reveals what frequencies exist in a signal and the strength of each frequency. The principle behind the Fourier Transform is simply that any signal can

be represented as a sum of simple sinusoids (sine and cosine waves) of different frequencies, amplitudes, and phases.

105. For a continuous signal, the Fourier Transform is expressed as follows:

$$F(\omega) = \int_{-\infty}^{\infty} X(f) e^{-j\omega t} df$$

where t = time, f = frequency and $\omega = 2\pi f$ = angular frequency in radians per second, j is the imaginary unit, e is Eulers number, and $e^{-j\omega t}$ is a complex sinusoid.

106. Related to the Fourier Transform is the Discrete Fourier Transform (DFT). Rather than addressing continuous signals, this equation deals with discrete data:

$$x[n] = \frac{1}{N} \sum_{k=0}^{N-1} X[k] e^{j\frac{2\pi}{N}kn}$$

where N is the total number of samples, k is the index of frequency, and $x[n]$ is the nth sample of the signal.

107. Also related is the Fast Fourier Transform, which is an algorithm to compute the Discrete Fourier Transform. There are variations of the Fast Fourier Transform developed at different times, each reducing the computational complexity of performing a DFT by (for example) minimizing the number of multiplications, making FFTs particularly useful in real-time signal processing.

108. The Inverse Fourier Transform (IFT) is the mathematical operation that reconstructs a time-domain signal from the frequency-domain representation. If the

Fourier Transform breaks a signal into frequency components (like taking apart a musical chord into notes), the Inverse Fourier Transform puts the frequency components back together (to rebuild the original signal):

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) e^{i\omega t} d\omega$$

As with the Fourier Transform, t = time, ω = angular frequency in radians per second, i is the imaginary unit; e is Eulers number, and $e^{i\omega t}$ is a complex sinusoid.

109. Just as the FFT is a practical way for calculating a Fourier Transform, an IFFT is a practical way for calculating an Inverse Fourier Transform.

9. Points

110. A POSITA would understand (FFT/IFFT) points to refer to discrete samples (specifically, subcarriers) used during the transformation from the time domain to the frequency domain or vice versa. In general, points refer to data samples from sampling for a process (such as FFT/IFFT).

111. In IEEE 802.11 systems, within which OFDM employs a set of frequency subcarriers that are converted from the frequency domain into the time domain by an IFFT, points refers to the number of subcarriers (samples) used during the computation, which is often referred to as the "length" (N) of the FFT/IFFT. For example, "64-point" FFT/IFFT involves 64 subcarriers while a "128-point"

FFT/IFFT involves 128 subcarriers. Accordingly, the number of subcarriers used for an OFDM symbol corresponds to the number of points of the IFFT.

112. As discussed above, however, not all of the 64 subcarriers for an IEEE 802.11a/g channel carry data. Instead, subcarriers at the edges of a channel are used for guard bands. Nonetheless, a 64 point IFFT would operate on all 64 subcarriers for a channel, regardless of how many of the subcarriers carry data. Guard band ("null") subcarriers would result in a null amplitude signal for the corresponding time interval.

10. Anti-aliasing

113. A POSITA would understand anti-aliasing to refer to use of low-pass filters to prevent aliasing artifacts when converting analog signals to digital format.

114. Aliasing occurs when a continuous-time analog signal (like a radio frequency signal) is sampled at a rate that is too low to capture the signal's true characteristics. Aliasing causes different frequency components to become indistinguishable from one another after digitization, and has been described as high-frequency signals "masquerading" as lower frequencies.

115. According to the Nyquist-Shannon Sampling Theorem, the sampling rate must be greater than or equal to the highest frequency component of a signal, to sample the signal accurately. This minimum sampling rate is known as the Nyquist rate. If the sampling rate is lower, higher frequency components "fold back" into the

lower frequencies, corrupting the digital representation. If aliasing occurs, undesired signals may interfere, leading to poor reception or misinterpretation. Typically, filters and mixers are used to isolate desired frequency bands.

116. Filtering, common in signal processing, is used to reduce or eliminate aliasing when sampling rates do not or cannot equal or exceed the Nyquist rate. Anti-aliasing is typically done with low pass or band pass (a/k/a "pass band") filters.

11. Packet

117. A POSITA would understand packet to refer to a unit of data. In the context of the '326 Patent, a POSITA would understand that unit of data to be larger than a single OFDM symbol.

118. In IEEE 802.11 systems, data packets (formally referred to as Medium Access Control (MAC) Protocol Data Units (MPDUs)) are the units of data exchanged over the air between devices like access points (APs) and stations (laptops, tablets, etc.). There are three types of 802.11 packets: management, control, and data. Management packets are used to manage the basic service set (BSS), control packets control access to the medium, and data packets contain payloads (OFDM symbols for data). The data packets constitute the majority of WiFi communication. Each data packet may contain a variable number of OFDM symbols, depending at least on the data rate.

12. Multiple Input, Multiple Output (MIMO)/Spatial Multiplexing

119. A POSITA would understand MIMO to refer to wireless technology that uses multiple transmitting and receiving antennas to improve communication performance. Although the term is not explicitly used in the claims of the '326 Patent, a POSITA would understand "transmitting to multiple radios" as describing MIMO.

120. Instead of relying on single transmitter and receiver antennas to send and receive data (single input, single output or "SISO"), MIMO systems employ multiple antennas at both the transmitter and receiver ends, enabling them to send more data simultaneously and more reliably. By using multiple antennas at both the transmitter and receiver, MIMO enables the creation of multiple independent data streams, allowing for simultaneous transmission and reception of data and resulting in a significant boost in overall data throughput and spectral efficiency.

121. Spatial multiplexing increases data rate by sending independent data streams from each transmitting antenna. These streams travel through different spatial paths and are separated at the receiver, allowing transmission of more bits per second without needing more bandwidth.

H. Gardner and Mori

1. Motivation to Combine Gardner and Mori

122. There are multiple motivations for a POSITA to make such a combination and reasons to believe it would be successful. As discussed in §II.B-D, both Gardner and Mori address improving data rates/data throughput by improving bandwidth utilization, both relate, explicitly or implicitly, to IEEE 802.11 systems, and both explicitly utilize OFDM and QAM. Both utilize multiple channels for communication by a transmitter. Ex.1006, 3:25-35, 3:59-63; Ex.1008, [0003], [0010]. A POSITA would therefore first realize that the technologies of both Gardner and Mori are compatible, and that the results of combining elements of Gardner with elements of Mori would have been predictable.

123. Gardner provides MIMO modulation and describes use of a "non-degenerate" MIMO system (Ex.1006, Fig.1A) in which "a transmitter splits the data into multiple streams and sends each via a separate antenna" "so that each transmitted data stream has a distinctive vector signature." Ex.1006, 2:51-55. "The receiver, which also has multiple antennas, processes received signals as including components from multiple transmitted streams, based on the differences in vector signatures of the transmitted streams." Ex.1006, 2:55-58. This results in an "increase the data rate and the operating range without increasing bandwidth" when "all network components … have additional RF chains and antennas." Ex.1006, 2:51-60. A POSITA would

understand Gardner to teach that the benefits of MIMO (spatial diversity, spatial multiplexing) can be achieved using multiple radios at the transmitter and receiver. A POSITA would also understand Gardner to teach that "non-degenerate" MIMO is compatible with IEEE 802.11.

124. While both Gardner and Mori disclose concurrently using multiple channels, Mori describes channel bonding and gap filling (e.g., Ex.1007, Figs. 8 and 9(f), Ex.1008, [0003], [0125]), which is distinct from MIMO. A POSITA would recognize such teachings as complementary to Gardner's discussion of "non-degenerate" MIMO. The channel bonding and gap filling of Mori can be used for each of the multiple transmitted streams from multiple antennas taught by Gardner.

125. For example, with channels B1, B2, B4, B5, and B8 available to "user C" but channels B3, B6, and B7 allocated to other users in Mori (see Ex.1008, [0074]), channel bonding and gap filling can be performed both for adjacent channel pair B1 and B2 (see Ex.1007, Fig. 9(f)) and for adjacent channel pair B4 and B5). The resulting OFDM symbols can then be transmitted using different antennas for channels B1/B2 and channels B4/B5, in a "non-degenerate" MIMO system as taught by Gardner. This would have been a combination of known methods with a reasonable expectation of success in providing an improved system with a higher data throughput for user C.

126. It would have been routine to add the above-mentioned features in Mori to the system of Gardner or vice versa. Furthermore, each element of the teachings from the respective references merely performs the same function as it does separately in the combination described. Combining the teachings of Mori with those of Gardner, considering Mori's goal of limiting wasted bandwidth and Gardner's objective of "higher data rates," would improve performance of the "non-degenerate" MIMO system in Gardner.

2. Claim Analysis

127. In the following sub-sections, I provide a claim-by-claim analysis of Gardner as combined with Mori disclosing the claim limitations of the '326 Patent. This would have been a combination of known elements with predictable results.

128. Certain claim elements recite substantially overlapping subject matter, and therefore, for efficiency and ease of understanding, I group these claim elements together. I note that all independent claims 1, 16, and 18 recite substantially similar acts or functions, stated in the same language in claims 1 and 18 but in slight different language in claim 16.

a. Claims [1.0], [16.0], [18.0]: Preambles

Claim	Limitations
[1.0]	A method for increasing data rates and data throughput in a network

[16.0]	A system for increasing data rates and data throughput in a network
[18.0]	A non-transitory computer-readable medium having instructions stored thereon

129. Gardner discloses a method for increasing data rates and throughput in a network. "[M]ultiple input, multiple output (MIMO) systems … increase the data rate and the operating range without increasing bandwidth" by splitting "[d]ata provided to transmitter 100 … into two streams," with "a first stream … sent via antenna 110a, while the second stream is sent via antenna 110b." Ex.1006, 2:50-51, 5:58-6:4. "The same MIMO modulation format is used for data transmission in any case. In a non-degenerate system (e.g., FIG. 1A), all the benefits of MIMO may be obtained, notably increased spectral efficiency (and thus, increased data rate) without increasing the required bandwidth or constellation density and without decreasing the operating range." Ex.1006, 11:7-12.

130. Gardner also discloses a system for increasing data rates and data throughput in a network. Gardner discloses a non-degenerate MIMO system including transmitter 100 with antennas 110a, 110b and receiver 150 with antennas 160a, 160b:

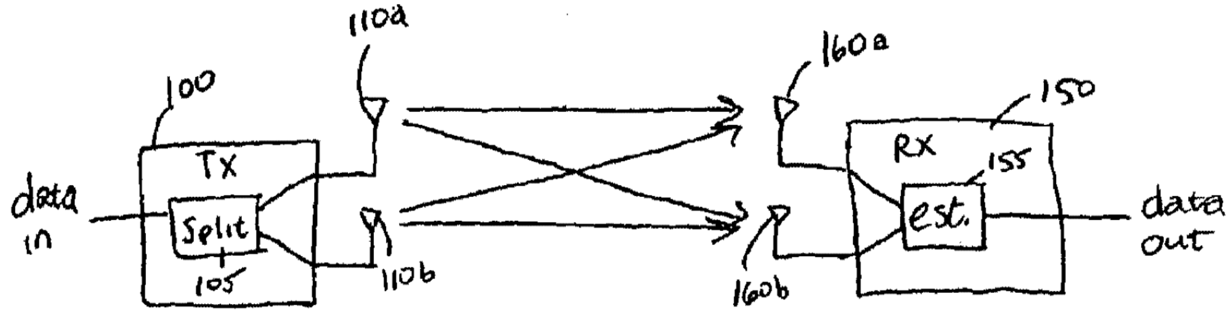


FIG. 1A

Ex. 1006, Fig. 1A, 5:58-6:20. "[A]ll the benefits of MIMO may be obtained, notably increased spectral efficiency (and thus, increased data rate) without increasing the required bandwidth or constellation density and without decreasing the operating range." Ex.1006, 11:7-12.

131. In addition to the explicit disclosure of increasing data rates bandwidth, a POSITA would understand that one of the benefits of using multiple transmitted streams as taught for non-degenerate MIMO in Gardner is increased data throughput.

132. Gardner describes a non-transitory computer-readable medium having instructions stored thereon. Gardner states that "the various components described herein may be implemented digital signal processors singly or in combination, or any other combination of hardware and/or software components." Ex.1006, 12:3-6. A POSITA would understand Gardner to disclose programmable DSPs and other hardware containing memory storing software instructions.

133. Mori also discloses a "method of utilizing a guard band between those unit communication bands for communication [that] increases frequency utilization efficiency and can further enhance the transmission speed of the information signals." Ex.1008, [0141].

134. Mori also discloses "a high-speed, large-capacity communication system" "using a predetermined number N of subcarriers having an IFFT 14 capable of simultaneously generating at least twice the number of subcarriers as N." Ex.1008, Abstract.

135. A POSITA would understand that one of the benefits of "increase[d] frequency utilization efficiency and … enhance[d] transmission speed of the information signals" as taught by Mori result from increasing data rates and data throughput, and that "high-speed, large-capacity communication" as disclosed by Mori comprises increased data rates and data throughput.

136. Mori discloses "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori necessarily employs hardware containing memory storing software instructions.

137. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

b. Claims [1.1], [16.1], [18.1]: selecting at least a first channel and a second channel

Claim	Limitations
[1.1]	selecting at least a first channel and a second channel, wherein the first channel and the second channel are adjacent without any other channels therebetween, wherein the first channel and the second channel each have a plurality of data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and second channels
[16.1]	means for selecting at least a first channel and a second channel, wherein the first channel is adjacent to the second channel without any other channels therebetween, wherein the first channel comprises a first plurality of subcarriers, and the second channel comprises a second plurality of subcarriers, wherein a frequency gap corresponding to at least one guard band between the first channel and the second channel separates the first plurality of subcarriers from the second plurality of subcarriers
[18.1]	instructions to select at least a first channel and a second channel, wherein the first channel and the second channel are adjacent without any other channels therebetween, wherein the first channel and the second channel each have a plurality of

	data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and second channels

138. Gardner discloses an "IEEE 802.11a extension[] that would support higher data rates" "us[ing] multiple channels to transmit the data stream; for example, data could be multiplexed between two 54 Mbps streams occupying two contiguous 20 MHz channels to obtain a rate of 108 Mbps." Ex.1006, 2:15-16, 2:17-20. A POSITA would recognize this as a description of channel bonding.

139. Gardner also discloses an exemplary non-degenerate MIMO system including transmitter 100 with antennas 110a, 110b and receiver 150 with antennas 160a, 160b:

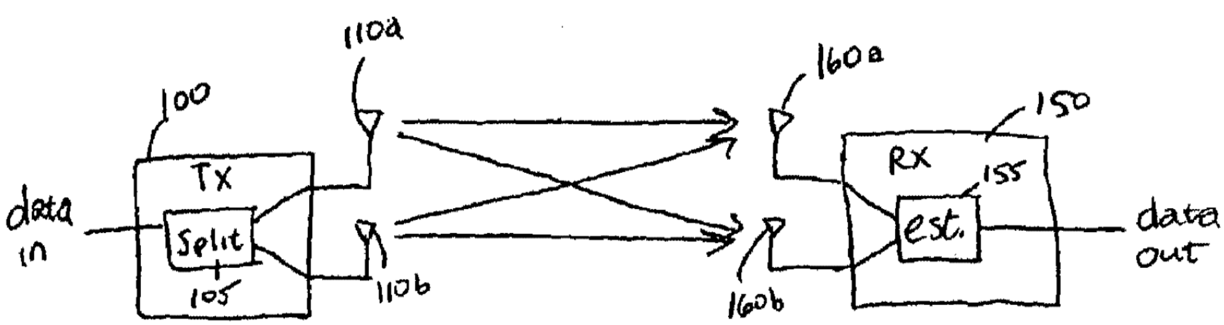


FIG. 1A

Ex.1006, Fig. 1A, 5:58-6:20. The "transmitter splits the data into multiple streams and sends each via a separate antenna," where "each transmitted data stream has a distinctive vector signature" and each "receiver, which also has multiple antennas, processes received signals as including components from multiple transmitted streams, based on the differences in vector signatures of the transmitted streams." Ex.1006, 2:51-58.

140. A POSITA would also understand the non-degenerate MIMO system of Gardner to be backwards compatible with IEEE 802.11a, as an "extension" of that standard. As an "extension," a POSITA would understand that the "multiple streams … each [sent] via a separate antenna data stream" by the transmitter the non-degenerate MIMO system should comprises different OFDM symbols based on separate IEEE 802.11a channels, in order to achieve "the benefits of MIMO…, notably increased spectral efficiency (and thus, increased data rate)" than IEEE 802.11a.

141. A POSITA would further understand that each IEEE 802.11a channel inherently has "a plurality of data subcarriers," with "the data subcarriers of" adjacent channels "separated by a frequency gap corresponding to one or more guard bands between the [adjacent] channels." See §III.G.3.

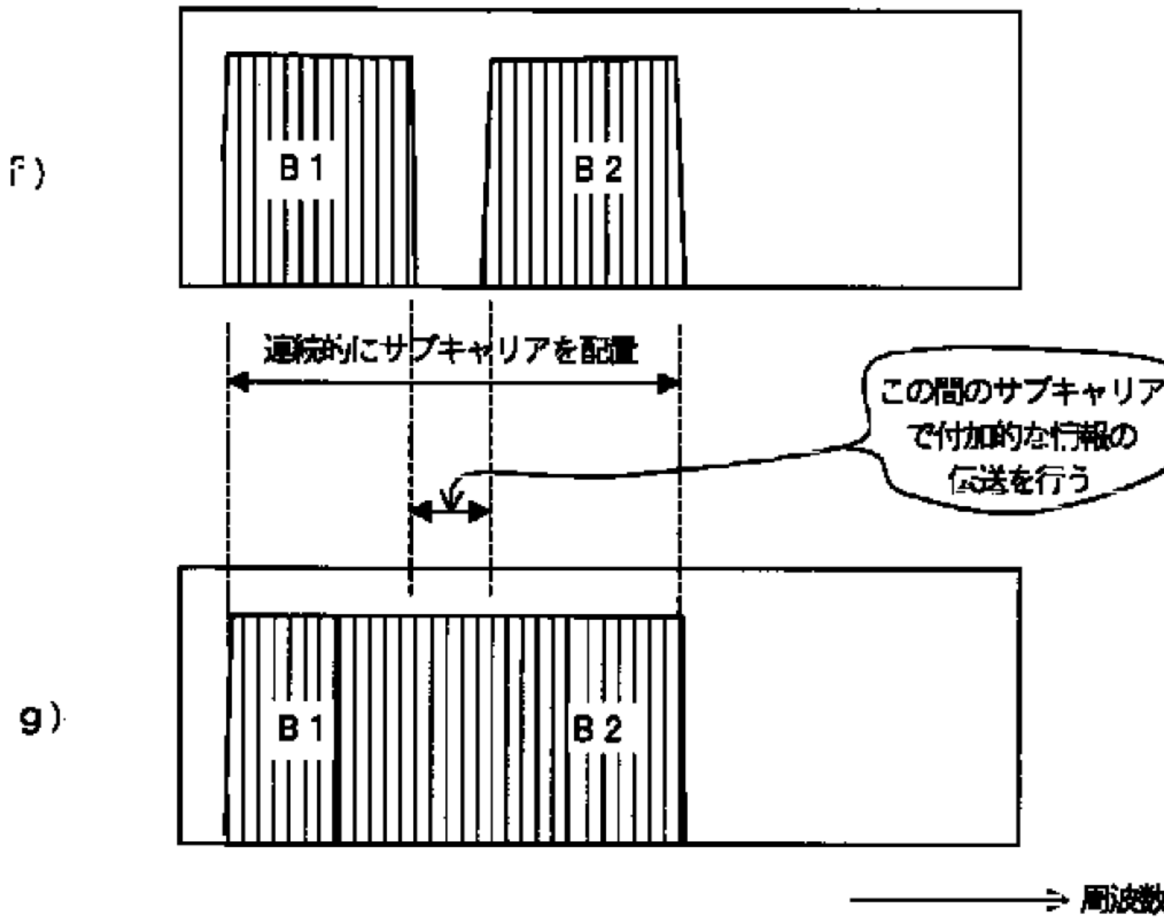
142. To the extent that Gardner does not explicitly disclose selecting channels that are adjacent without any other channels within the frequency gap therebetween, this would have been obvious to a POSITA combining channel bonding with MIMO. OFDM symbols for adjacent, channel bonded IEEE 802.11a channels necessarily involves selecting adjacent channels.

143. Mori also discloses using IEEE 802.11a-type channels: “The practical wireless access system uses a bandwidth of 100 MHz in the 5 GHz band, with four channels spaced 20 MHz apart, and communication is conducted through each channel” in which “the transmission method used is OFDM” and “the spacing between each carrier is set to 312.5 kHz.” Mori, Ex.1008, [0003]-[0005].

144. In a specific example, Mori states that “user C is in a situation where communication is performed by setting three of the remaining B1, B2, B4” among channels B1 through B8, and describes “multi-carrier signals for communication using B1, B2.” Ex.1008, [0074]-[0075].

145. Mori depicts and explicitly describes “adjacent bands B1 and B2.” Ex.1008, [0121]. While describing Fig. 8(c), a POSITA would recognize that the statement also describes Figs. 9(f)-(g), which are reproduced below:

【図9】



Ex.1007, Figs. 9(f)-(g); see also Fig. 8(c). A POSITA would recognize that, in Fig. 9(f) of Mori, "the first channel [B1] and the second channel [B2] are adjacent without any other channels therebetween," and that "the first channel [B1] and the second channel [B2] each have a plurality of data subcarriers." Figs. 9(f)-(g) and the associated description of Mori implicitly disclose "selecting" adjacent channels B1 and B2.

146. Because Mori states that Fig. 9(f) "illustrates an arrangement of subcarriers having conventional guard bands" (Ex.1008, [0128]), a POSITA would recognize that "the data subcarriers of the first channel [B1] and the data subcarriers of the second channel [B2] are separated by a frequency gap corresponding to one or more guard bands between the first and second channels" [B1] and [B2].

147. A POSITA would be motivated to select the "adjacent bands B1 and B2" of Mori for the "multiple streams … each [sent] via a separate antenna data stream" of Gardner based on suitability for obtaining "the benefits of MIMO…, notably increased spectral efficiency (and thus, increased data rate) without increasing the required bandwidth or constellation density and without decreasing the operating range." Ex.1006, 11:7-12.

148. Gardner discloses that the transmitter 100 includes a splitter 105 splitting into two streams for transmission via antennas 110a and 110b. Gardner therefore discloses a "means for selecting at least a first channel and a second channel."

149. Gardner states that "the various components described herein may be implemented digital signal processors singly or in combination, or any other combination of hardware and/or software components." Ex.1006, 12:3-6. A POSITA would recognize that an implementation of transmitter 100, including splitter 105, as a combination of hardware and software would include "instructions to select at least a first channel and a second channel."

150. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2. Mori therefore discloses a "means for selecting at least a first channel and a second channel."

151. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori discloses "instructions to select at least a first channel and a second channel."

152. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

c. Claims [1.2], [16.2], [18.2]: partially filling the frequency gap with data subcarrier[s]

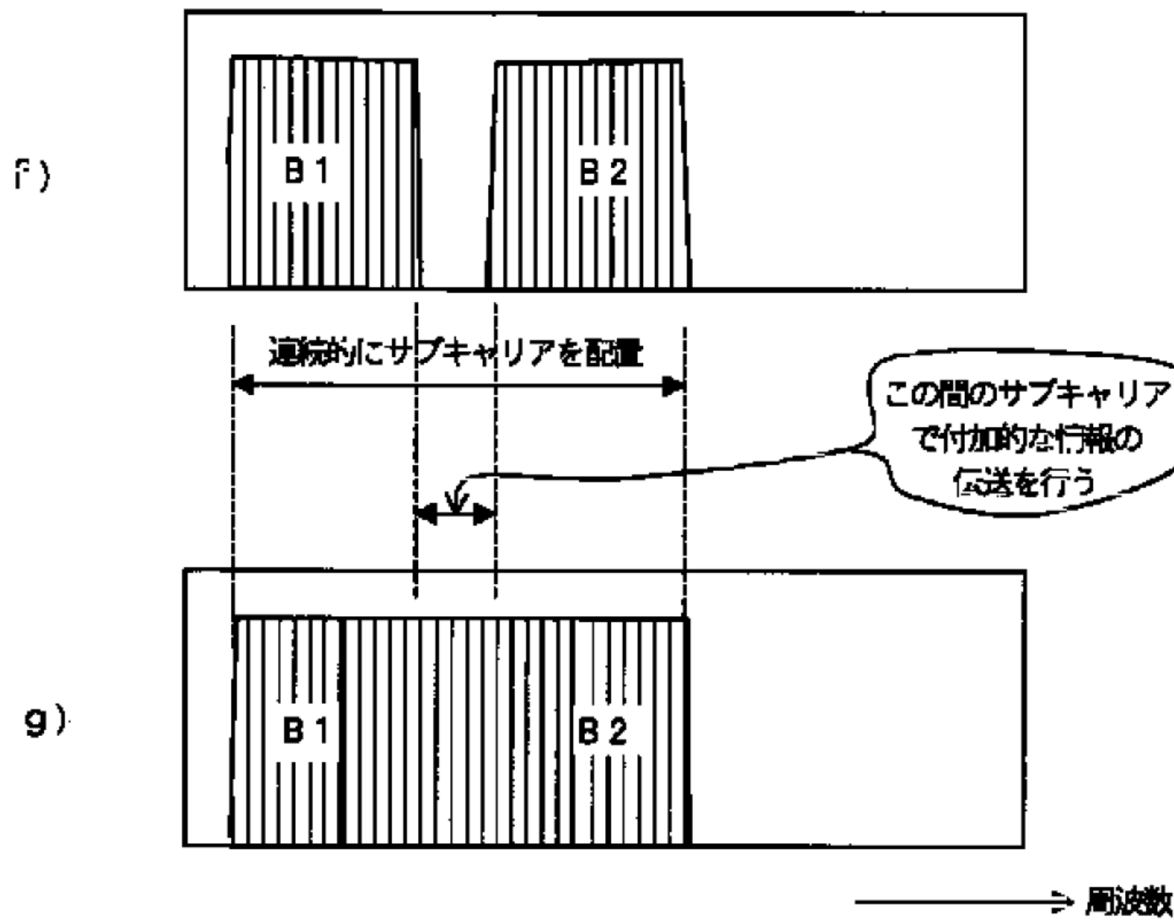
Claim	Limitations
[1.2]	partially filling the frequency gap between the first channel and the second channel by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data

	subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform
[16.2]	means for partially filling the frequency gap with at least one additional subcarrier such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform
[18.1]	instructions to partially fill the frequency gap between the first channel and the second channel by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform

153. Mori discloses "continuously arranging multi-carrier signals … to increase the number of multi-carriers compared to when guard bands are provided, resulting in a larger transmission rate." Ex.1008, [0123]. Embodiments of Mori achieve an "increase in transmission rate due to the increase in subcarriers" by "the addition of 10 subcarriers in the guard band area." Ex.1008, [0125]. Mori graphically depicts "a case where subcarriers are arranged consecutively in consecutive bands" by "addition of 10 subcarriers in the guard band area" to "increase the number of data carriers by allocating subcarrier data to the guard band between the consecutive bands B1 and B2" to obtain an "increase the number of multi-carriers compared to

when guard bands are provided, resulting in a larger transmission rate." Ex.1008, [0123], [0125], [0128], [0132]. These statements describe Figs. 9(f)-(g) of Mori, which are reproduced below.

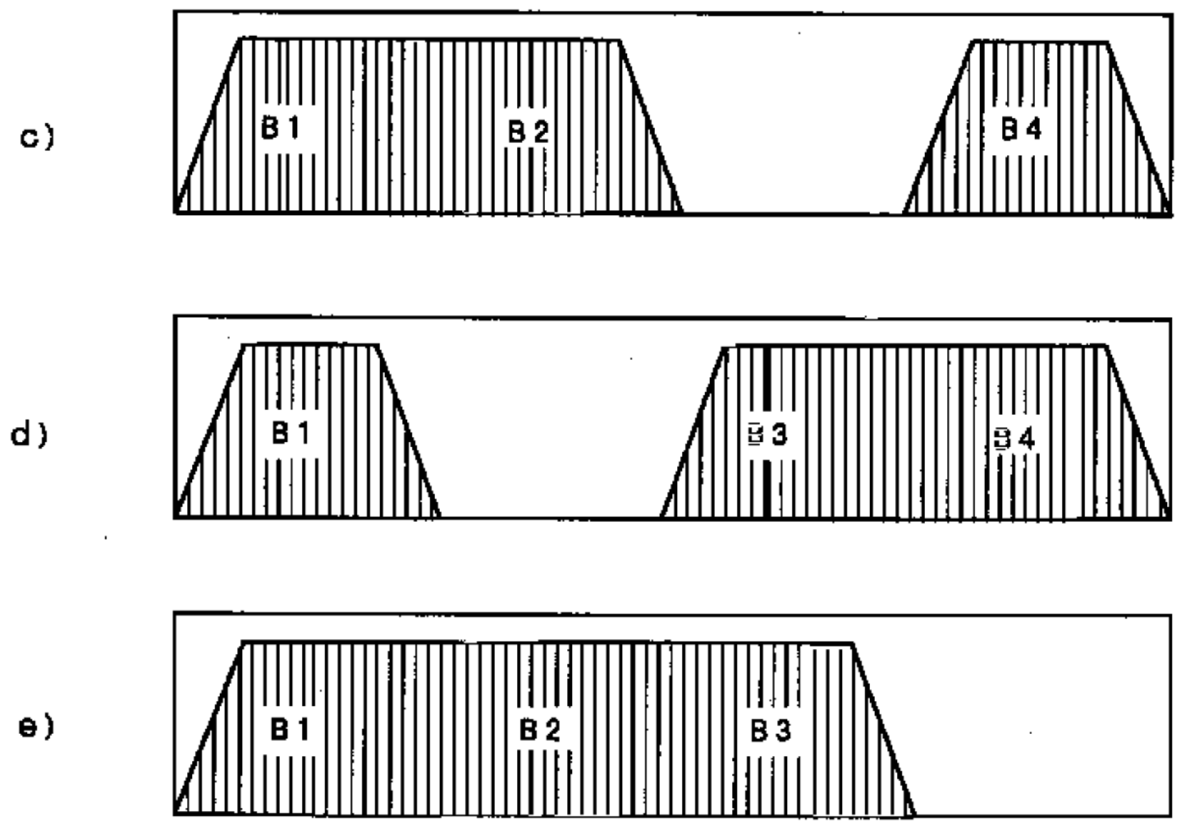
【図9】



Ex.1007, Figs. 9(f)-(g). "In this way, the area of the guard band may be effectively utilized." Ex.1008, [0131].

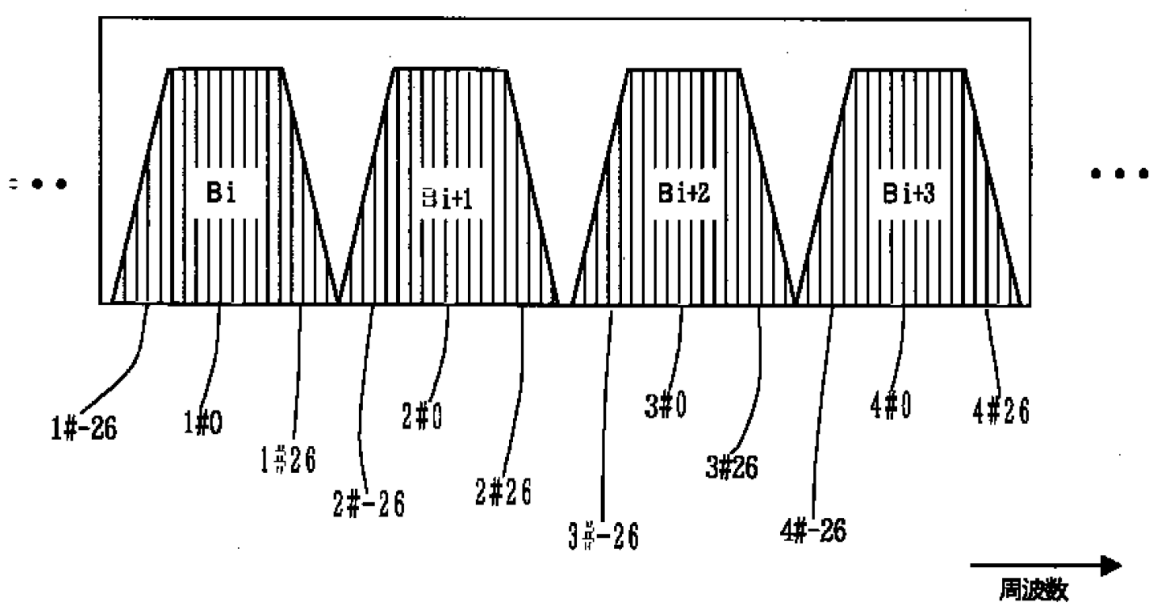
154. Mori discloses other examples of using the guard band(s) between adjacent channels to carry data. For instance, Figs. 8(c)-(e) of Mori are reproduced below:

【図8】



Ex.1007, Figs. 8(c)-(e). Mori states that these figures illustrate "state where subcarriers are arranged consecutively in bands that are used continuously", with Fig. 8(c) illustrating "signals using three bands B1, B2, and B4, where consecutive multi-carrier signals are arranged between the adjacent bands B1 and B2," Fig. 8(d) illustrating "consecutive multi-carrier signals are arranged between the consecutive bands B3 and B4," and Fig. 8(e) illustrating that, "since bands B1 to B3 are used consecutively, consecutive multi-carrier signals are arranged in bands B1 to B3." Ex. 1008, [0120]-[0122]. By contrast, Fig. 4 of Mori illustrates, for four consecutive bands, "the frequency band and the positions of the subcarrier frequencies within that band." Ex.1008, [0069]. Fig. 4 of Mori is reproduced below.

【図4】



Ex.1007, Fig. 4. A POSITA would recognize that the channel labeled "Bi" in Fig. 4 corresponds to channel B1 in Figs. 8(c)-(e) and 9(f)-(g), the channel labeled "Bi+1" in Fig. 4 corresponds to channel B2 in Figs. 8(c)-(e) and 9(f)-(g), The channel labeled "Bi+2" in Fig. 4 corresponds to channel B3 in Figs. 8(c)-(e), and the channel labeled "Bi+3" in Fig. 4 corresponds to channel B1 in Figs. 8(c)-(e).

155. A POSITA would therefore understand that Fig. 8(c) illustrates channels B1 and B2 with the guard band therebetween filled with data subcarriers (similar to Fig. 9(g), Fig. 8(d) similarly illustrates channels B3 and B4 with the guard band therebetween filled with data subcarriers, and Fig. 8(e) illustrates channels B1, B2, and B3 with two guard bands filled with data subcarriers.

156. Mori therefore discloses "[at least partially] filling the frequency gap between the first channel [B1] and the second channel [B2] by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers." To the extent the '326 Patent requires the frequency gap to be partially rather than completely filled, it would be obvious to a POSITA to modify the teachings of Mori such that a frequency gap is only partially filled with data subcarriers.

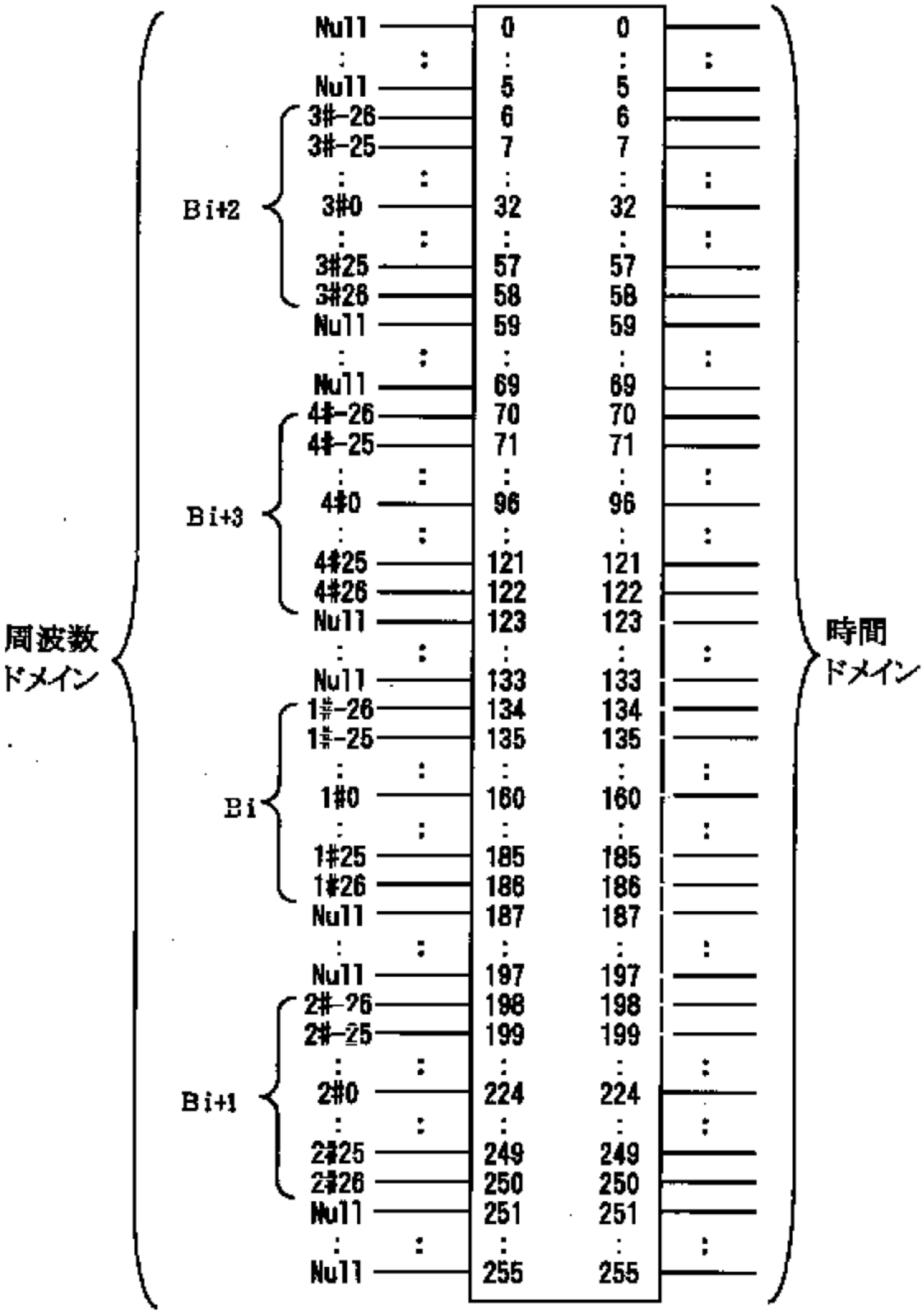
157. A POSITA would understand "using full spectral synthesis capability of a fast Fourier transform or an inverse fast Fourier transform" to be satisfied by use of an IFFT on all subcarriers of a channel, including the subcarriers within the frequency gap corresponding to a guard band. The '326 Patent describes "using a full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)" as "achieved, for example, by 1) using two existing legacy circuits or radios in parallel (2-64 point FFTs that process two halves of the signal (1-upper and

1-lower)) or 2) by using a single circuit that processes the whole signal (1-128 point FFT).” Ex.1001, 10:51-52, 11:23-27.

158. Gardner describes “[e]ach of OFDM modulators 221, 222” as “perform[ing] OFDM modulation using an inverse fast Fourier transform (IFFT), thereby providing a time-domain signal” for one of “two streams” from splitter 105 that uses “any…algorithm employed in existing MIMO systems.” EX.1006, Fig. 1A, 7:57-65, 8:1-4. A POSITA would understand that, by using IFFT, Gardner’s OFDM modulators “us[e the] full spectral synthesis capability of…an inverse fast fourier transform.”

159. Mori depicts and describes “a 256-point IFFT processor performing 64-point IFFT operations simultaneously” on the four consecutive channels B1, B2, B3, and B4. Ex.1008, [0066].

【図３】



周波数ドメイン
時間ドメイン
Bi+2
Bi+3
Bi
Bi+1
Null
3#-26
3#-25
3#0
3#25
3#26
4#-26
4#-25
4#0
4#25
4#26
1#-26
1#-25
1#0
1#25
1#26
2#-26
2#-25
2#0
2#25
2#26
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Ex.1007, Fig. 3. The four channels in Fig. 3 are labeled "Bi", "Bi+1", "Bi+2", and "Bi+3," which respectively correspond to channels B1, B2, B3, and B4 as discussed above. In the example of using channels B1 and B2 with the guard band therebetween filled with data subcarriers (see Fig. 9(g)), Mori states that "data allocation may be made for 10 subcarriers at 10 input terminals … among input terminals 187 to 197" depicted for the 256 point IFFT processor in Fig. 3. Ex.1008, [0124].

160. Mori teaches that, by using the 256-point IFFT processor of Fig. 3 to simultaneously perform 64-point IFFT operations on multiple channels, "there is no need to provide … guard bands" "because the OFDM signals of multiple bands generated by a single IFFT are orthogonal to each other, and thus do not interfere with one another." Mori, Ex. 1008, [0117]. Further, "[e]ven when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for the omission of guard bands." Mori, Ex. 1008, [0118].

161. A POSITA would therefore recognize that the 256-point IFFT processor of Fig. 3 in Mori "us[es] full spectral synthesis capability of a fast Fourier transform or an inverse fast Fourier transform" when operating on "adjacent bands B1 and B2"

with "10 subcarriers in the guard band area" between channels B1 and B2, as disclosed by Mori.

162. A POSITA would recognize that "increas[ing] the number of multi-carriers compared to when guard bands are provided, resulting in a larger transmission rate," by "data allocation may be made for 10 subcarriers" "in the guard band area" as taught by Mori is distinct from, but also compatible with, the "multiple streams … each [sent] via a separate antenna data stream" of Gardner and the attendant "benefits of MIMO…, notably increased spectral efficiency (and thus, increased data rate) without increasing the required bandwidth or constellation density and without decreasing the operating range." A POSITA would have been motivated to combine the above-described teachings of Gardner and Mori in order to obtain the benefits of both approaches.

163. Mori explicitly discloses an IFFT calculator receiving data on subcarriers between two channels that correspond to a guard band region between the channels. Gardner discloses that the transmitter 100 includes a splitter 105 splitting into two streams for transmission via antennas 110a and 110b. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses a "means for filling the frequency gap" between adjacent channels with "data subcarrier[s]."

164. Gardner states that "the various components described herein may be implemented digital signal processors singly or in combination, or any other

combination of hardware and/or software components." Ex.1006, 12:3-6. A POSITA would recognize that Gardner, when combined with Mori as described above and implemented as a combination of hardware and software, discloses a "instructions to fill the frequency gap" between adjacent channels with "data subcarrier[s]."

165. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2. Mori therefore discloses a "means for filling the frequency gap" between adjacent channels with "data subcarrier[s]."

166. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori discloses "instructions to fill the frequency gap" between adjacent channels with "data subcarrier[s]."

167. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

d. Claims [1.3], [16.3], [18.3]: combining channels using channel bonding with OFDM

Claim	Limitations
[1.3]	combining the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)
[16.3]	means for combining the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)
[18.3]	instructions to combine the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)

168. A POSITA would understand "channel bonding with orthogonal frequency division multiplexing (OFDM)" to be satisfied by use of IFFTs operating separately on each channel. The '326 Patent describes use of "multi-chain radios each with a single bandwidth and multiple FFTs, multiple converters, and multiple analog filters" as "a form of 'channel bonding'." Ex.1001, 12:13-15.

169. Gardner explicitly describes an option "for IEEE 802.11a" extension as "us[ing] multiple channels to transmit the data stream; for example, data could be multiplexed between two 54 Mbps streams occupying two contiguous 20 MHz channels to obtain a rate of 108 Mbps." Ex.1006, 2:15-20. Gardner also describes "[e]ach data stream [as being] independently modulated using, for instance,

orthogonal frequency division multiplexing (OFDM) modulation," stating that "[e]ach of OFDM modulators 221, 222, which may be implemented using standard components, performs OFDM modulation using an inverse fast Fourier transform (IFFT) [one of two streams from splitter 105 that uses any algorithm employed in existing MIMO systems], thereby providing a time-domain signal suitable for feeding to an antenna." Ex.1006, 3:30-33, 7:57-65, 8:1-5. A POSITA would recognize these portions of Gardner as disclosing channel bonding using OFDM.

170. Mori also discloses using OFDM, stating that "each channel has a unit communication bandwidth of 20 MHz, enabling transmission at 20 Mbps or more. The transmission method used is the OFDM method, which is resistant to multipath interference caused by waves reflected by buildings, walls, etc., and has high frequency utilization efficiency." Ex.1008, [0005].

171. In a specific example of channel bonding and gap filling between channels B1 and B2, Mori depicts and describes "the addition of 10 subcarriers in the guard band area" between those two channels. Ex.1007, Fig. 9, Ex.1008, [0125]. Mori also depicts and describes "a 256-point IFFT processor performing 64-point IFFT operations simultaneously" on the four consecutive channels B1, B2, B3, and B4. Ex.1007, Fig. 3, Ex.1008, [0066]. Mori teaches that, by using the 256-point IFFT processor of Fig. 3 to simultaneously perform 64-point IFFT operations on multiple channels, "the OFDM signals of multiple bands generated by a single IFFT are

orthogonal to each other, and thus do not interfere with one another." Ex. 1008, [0117]. "Even when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal." Ex. 1008, [0118].

172. Mori explicitly discloses one or more IFFT calculators generating OFDM symbols for the two channels using all 64 subcarriers for each channel. Gardner discloses that the transmitter 100 includes a splitter 105 splitting into two streams for transmission via antennas 110a and 110b. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses a "means for combining" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)."

173. Gardner states that "the various components described herein may be implemented digital signal processors singly or in combination, or any other combination of hardware and/or software components." Ex.1006, 12:3-6. A POSITA would recognize that Gardner, when combined with Mori as described above and implemented as a combination of hardware and software, discloses a "instructions to combine" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)."

174. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2, and the 256-point IFFT processor of Fig. 3 simultaneously performs 64-point IFFT operations on multiple channels. Mori therefore discloses a "means for combining" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)."

175. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori discloses "instructions to combine" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)."

176. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

e. Claims [1.4], [16.4], [18.4]: transmitting the first plurality of subcarriers, the second plurality of

subcarriers, and the at least one additional subcarrier in parallel

Claim	Limitations
[1.4]	transmitting data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel to a receiver
[16.4]	means for transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel to a receiver
[18.4]	instructions to transmit data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel to a receiver

177. A POSITA would understand "in parallel" to be satisfied by either (a) channel subcarriers that are parallel (non-overlapping) in frequency, or (b) use of spatial diversity (MIMO). The '326 Patent describes "two parallel channels" employed for "concatenation of two (or more) channels using parallel transceivers at the transmit and/or receive end" as involving "parallelizing the signals in frequency." Ex.1001, 4:6, 8:5, 11:29-30, 11:47-48. The '326 Patent also states that "a dual chain wideband radio receiver" employing "two channels in parallel" (e.g., "multiple, parallel receive chains designed to receive a single narrow signal") necessitates "a dual channel protocol", such as "instruct[ing] all legacy radios to go to channel 2 and stay off of channel 3 to prevent collision." Ex.1001, 12:65-66, 13:9-13, 14:20-21. A POSITA would therefore understand "data subcarriers occupying the first channel,

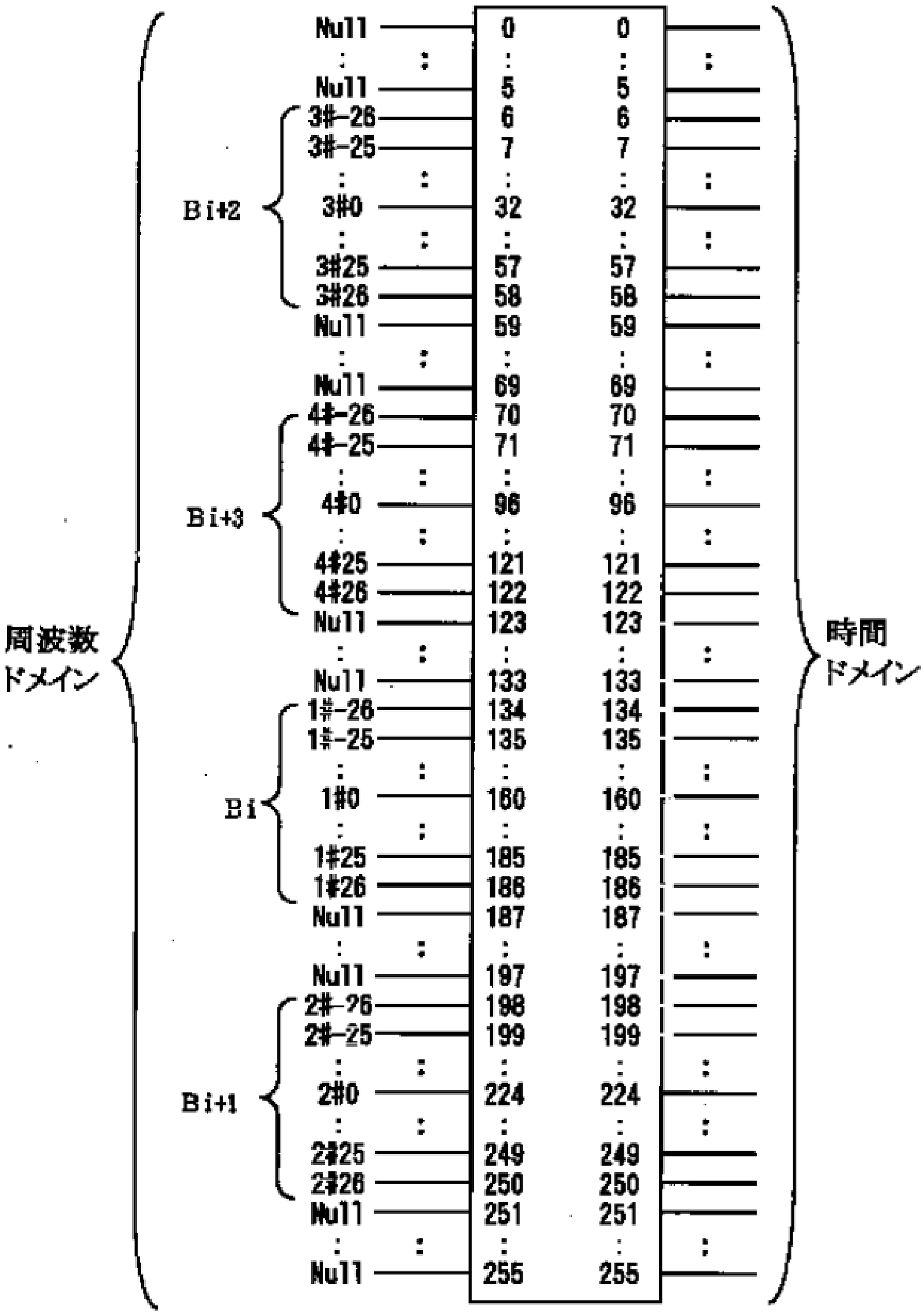
the second channel, and the frequency gap in parallel" to be satisfied by sets of subcarriers that are parallel in frequency occupying the channels and the frequency gap. However, the '326 Patent also describes a result of "using multiple input multiple output (MIMO)" (that is, "spatial multiplexing … using MIMO technique") is that "the bandwidth is doubled with two signals in parallel." Ex.1001, 5:53-54, 12:54, 12:59-60. A POSITA would therefore understand "transmitting … in parallel to a receiver" to be satisfied by use of MIMO.

178. Gardner describes that, using "a communication system comprising a plurality of transmitters and receivers configured to transmit and receive data in parallel via a plurality of channels, a process for transmitting data is provided." Ex.1006, 3:25-29. As discussed above, Gardner discloses that the transmitter 100 includes a splitter 105 splitting into two streams for transmission via antennas 110a and 110b. Gardner therefore discloses two signal outputs from the splitter 105 suitable for coupling with two antennas 110a, 110b. Gardner describes "OFDM modulators 221, 222…[as] perform[ing] OFDM modulation using an inverse fast Fourier transform (IFFT), thereby providing a time-domain signal" for one antennas 110a, 110b. EX.1006, Fig. 1A, 7:57-65, 8:1-4. POSITAs would understand OFDM modulators 221, 222 to generate separate OFDM symbols for antennas 110a, 110b. When using channel bonding as described in Gardner, the resulting OFDM symbols for adjacent channels would be split by splitter 105, with one of the two OFDM symbols transmitted by

antenna 110a and the other of the two OFDM symbols transmitted by antenna 110b. In the non-degenerate MIMO described in Gardner, the spatial transmission path from antenna 110a and the spatial transmission path from antenna 110b are parallel.

179. Mori discloses that a "practical wireless access system uses a bandwidth of 100 MHz in the 5 GHz band, with four channels spaced 20 MHz apart, and communication is conducted through each channel." Mori, Ex.1008, [0003]. As discussed above, Mori describes transmitting data for user C on adjacent channels B1 and B2 with the guard band therebetween filled with data subcarriers. Mori discloses that the "multi-carrier signal generation device 10" used to transmit data for user C on adjacent channels B1 and B2 (and on data subcarriers in the intervening guard band). Channel B1 and its associated guard band subcarriers and channel B2 and its associated guard band subcarriers are parallel (non-overlapping) in frequency. Multi-carrier signal generation device 10 includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor includes outputs 0 to 255 for outputting the results of the four 64-point IFFTs in parallel, as shown in Fig. 3 reproduced below.

【図3】



周波数
ドメイン
時間
ドメイン
Bi+2
Bi+3
Bi
Bi+1
Null
3#-26
3#-25
3#0
3#25
3#26
4#-26
4#-25
4#0
4#25
4#26
1#-26
1#-25
1#0
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Ex.1007, Fig. 3. Mori therefore discloses signal outputs from the 256-point IFFT processor suitable for coupling with one or more antennas.

180. Mori explicitly discloses a 256-point IFFT processor generating OFDM symbols for the two adjacent channels B1 and B2 using all 64 subcarriers for each channel, including the terminals for channel edge subcarriers that would receive a "Null" signal if a guard band is employed but receive data subcarriers.

181. When adjacent channels B1 and B2 with data subcarriers inserted into the guard band(s) therebetween, as disclosed in Mori, are combined with Gardner's non-degenerate MIMO, splitter 105 will either (a) direct the two OFDM symbols for channels B1 and B2 (and associated guard band region data subcarriers) to one of antennas 110a or 110b, or (b) split the two OFDM symbols for channels B1 and B2 (and associated guard band region data subcarriers) between antennas 110a and 110b. In either case, channel B1 and its associated guard band subcarriers and channel B2 and its associated guard band subcarriers are parallel (non-overlapping) in frequency, and the spatial transmission path from antenna 110a and the spatial transmission path from antenna 110b are parallel.

182. Gardner discloses splitting received data for transmission on separate antennas 110a, 110b. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses a "means for transmitting the first plurality of

subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

183. Gardner states that "the various components described herein may be implemented digital signal processors singly or in combination, or any other combination of hardware and/or software components." Ex.1006, 12:3-6. A POSITA would recognize that Gardner, when combined with Mori as described above and implemented as a combination of hardware and software, discloses "instructions to transmit the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

184. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2, and the 256-point IFFT processor of Fig. 3 simultaneously performs 64-point IFFT operations on multiple channels. Mori therefore discloses a "means for transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

185. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily

programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. The 256-point IFFT has parallel outputs for the four 64-point IFFTs performed simultaneously therein. A POSITA would recognize that Mori discloses "instructions to transmit the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

186. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

f. Claim [2.0] interleaving legacy and wide signals

Claim	Limitations
[2.0]	The method of claim 1, wherein combining the first channel and the second channel further comprises: interleaving one of a legacy signal and a wide signal during packet transmission

187. A POSITA would note that, in the '326 Patent, "legacy signals" simply means one channel and "wide signals" simply means multiple (channel bonded) channels. Ex.1001, 14:7-8. Therefore, interleaving a legacy (one-channel) signal with a wide (multi-channel) signal would be well understood to a POSITA. The '326 Patent states that "[l]egacy signals (e.g., one-channel) and wide signals (e.g., multiple-channels) may be arbitrarily interleaved in time (dynamic bandwidth switching) during packet transmission." Ex.1001, 14:710. A POSITA would understand

"interleaving" as satisfied by sending the "legacy signals" and the "wide signals" at different times or in different data packets.

188. Gardner teaches that, "[a]fter splitting the data, coordinate interleaving may be performed using pseudorandom or periodic interleavers," with "each coordinate interleaver configured to receive one of the plurality of data streams from the demultiplexer, to coordinate interleave the received data stream" because "coordinate interleaving increases the diversity order of the system by providing additional redundancy." Gardner, Ex.1006, 3:46-52, 4:43-44, 7:47-48.

189. Gardner describes extending IEEE 802.11a to "support higher data rates" "us[ing] multiple channels to transmit the data stream; for example, data could be multiplexed between two 54 Mbps streams occupying two contiguous 20 MHz channels" (i.e., channel bonding, see EX.1004, ¶138). EX.1006, 2:15-16, 2:17-20. Gardner also describes extending IEEE 802.11a by "us[ing] multiple input, multiple output (MIMO) systems to increase the data rate and the operating range without increasing bandwidth," through "a transmitter split[ting] the data into multiple streams and send[ing] each via a separate antenna" with "a distinctive vector signature" that the "receiver, which also has multiple antennas," uses to "process[] received signals" and discriminate the "multiple transmitted streams, based on the differences in vector signatures of the transmitted streams." EX.1006, 2:49-58.

190. A POSITA would understand channel bonding and MIMO to be distinct but compatible technologies, suitable for use either separately or together.

191. A POSITA would also recognize that channel bonding will not always be used. For the two data streams from the splitter 105 in Gardner, a POSITA would understand that differences exist in the size "one data stream relative to the other." See Ex.1006, 8:23. Since data streams are unlikely to always have sufficient data for OFDM symbols pairs, interleaving of "wide" OFDM symbol pairs for channel bonding and "legacy" single OFDM symbols will necessarily occur.

192. Mori describes "a multi-carrier signal is generated using the bandwidths B1, B2, and B4 for user C to communicate using the multi-carrier signal." Ex.1008, [0077], see also [0090]. In the example, channel bonding and gap filling are used for channels B1 and B2 while channel B4 is used alone. Ex.1007, Fig. 9(c), Ex.1008, [0121]. A POSITA would understand the data packet(s) for channel bonded and gap filled channels B1 and B2 are necessarily interleaved with data packets for channel B4.

193. A POSITA would recognize that Gardner, when combined with Mori as described above, suggests data packet(s) for channel bonded and gap filled channels B1 and B2 (a "wide" signal) with data packets for channel B4 alone (a "legacy" signal) to "increase[] the diversity order of the system."

194. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

g. Claim [3.0] legacy and wide signals

Claim	Limitations
[3.0]	The method of claim 2, wherein the legacy signal comprises one channel and the wide signal comprises multiple channels.

195. As discussed above, Mori describes "a multi-carrier signal is generated using the bandwidths B1, B2, and B4 for user C to communicate using the multi-carrier signal." Ex.1008, [0077], see also [0090]. In the example, channel bonding and gap filling are used for channels B1 and B2 while channel B4 is used alone. Ex.1007, Fig. 9(c), Ex.1008, [0121].

196. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses transmitting channel bonded and gap filled channels B1 and B2 (a "wide" signal) and channel B4 alone (a "legacy" signal).

197. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

h. Claim [4.0] transmitting to multiple radios

Claim	Limitations
[4.0]	The method of claim 1, wherein transmitting the first channel and the second channel comprises transmitting to multiple radios

198. A POSITA would first notice that a wireless signal is inherently transmitted to multiple radios when multiple radio receivers are in range of the transmitter.

199. To the extent that an intent is read into the claim language (i.e., that "the first channel and the second channel" are intended for "multiple radios"), a POSITA would understand "transmitting to multiple radios" to be satisfied by "using two existing legacy circuits or radios in parallel" using MIMO. Ex.1001, 11:24. The '326 Patent teaches that "the high data rate multi-channel arrangement of the invention may be achieved, for example, by 1) using two existing legacy circuits or radios in parallel" with "one physical implementation of a dual-chain wideband radio" using "a 'multiple radios in a box' implementation" in which "multi-chain radios each with a single bandwidth … are used." Ex.1001, 11:24-26, 12:9-15.

200. Gardner discloses that "multiple input, multiple output (MIMO) systems … increase the data rate and the operating range without increasing bandwidth" by splitting "[d]ata provided to transmitter 100 … into two streams," with "a first stream … sent via antenna 110a, while the second stream is sent via antenna 110b." Ex.1006, 2:50-51, 5:58-6:4. Gardner teaches that "MIMO systems require all network components to have additional RF chains and antennas" and that "'antenna' refers generally to any apparatus for coupling a transmitter or receiver to a channel and is to be understood as including any associated components such as a standard radio-frequency (RF) chain." EX.1006, 2:59-60, 5:65-6:1. As discussed above, Fig.

1A of Gardner discloses a non-degenerate MIMO system including transmitter 100 with antennas 110a, 110b. EX.1006, Fig.1A, 6:1-4. A POSITA would therefore understand antennas 110a, 110b to include separate RF chains. In addition, the non-degenerate MIMO system includes receiver 150 with antennas 160a, 160b. "Receiver 150 receives a first signal via antenna 160a and a second signal via antenna 160b" and, since "the signals received by antennas 160a, 160b are expected to be different in some way," "includes an estimator unit 155 that decombines the two signals in order to estimate the transmitted data sequence." Ex.1006, 6:9-20. A POSITA would understand the antennas 110a, 110b to transmit to multiple radios.

201. Mori describes three users (user A, user B, and user C) sharing eight channels B1 through B8. "[A]mong bandwidths B1 to B8, B3 indicated as a) is already used by user A, and B6 and B7 are already used by user B, while user C is in a situation where communication is performed by setting three of the remaining B1, B2, B4, B5, and B8 bandwidths." EX.1008, ¶[0074]. In one example, "a multi-carrier signal is generated using the bandwidths B1, B2, and B4 for user C to communicate using the multi-carrier signal generation device," for "communicating using multiple unit communication [channels], even when they are not consecutive, thus improving channel utilization efficiency." EX.1008, ¶¶[0075], [0077], [0148]. POSITAs would understand that the multi-carrier signal for channels B1, B2, and B4 transmitted via

antenna 19 in Mori would be transmitted to radios for user A and user B, which share the same channels.

202. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses transmitting channel bonded and gap filled channels B1 and B2 to multiple radios.

203. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

i. Claim [5.0] transmitting to a single radio

Claim	Limitations
[5.0]	The method of claim 1, wherein transmitting the first channel and the second channel comprises transmitting to a single radio

204. As discussed above, a POSITA would understand that a wireless signal is inherently transmitted to the number of radios that are in range of the transmitter. If only a single radio is in range, the signal is transmitted to that single radio.

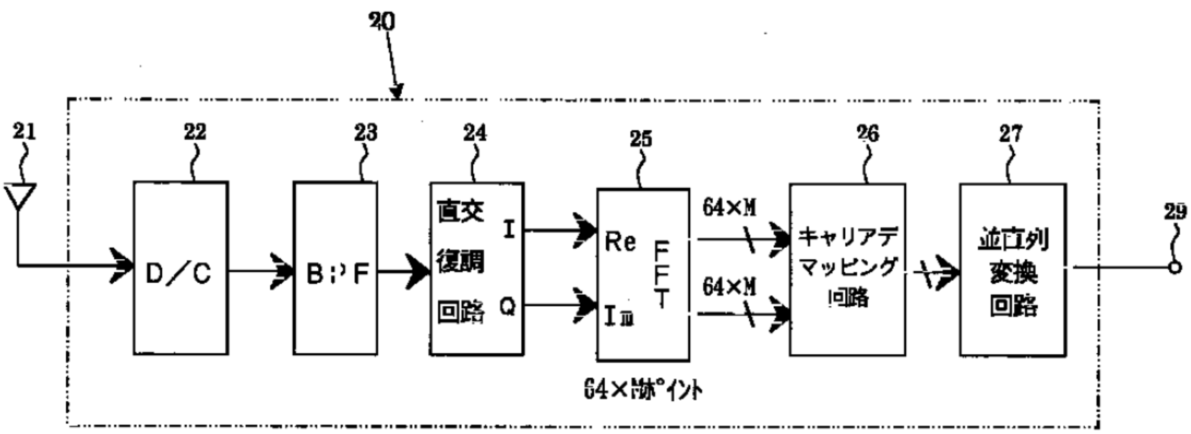
205. To the extent that an intent is read into the claim language (i.e., that "the first channel and the second channel" are intended for "a single radio"), Mori explicitly discloses receiving channel bonded and gap-filled adjacent channels B1 and B2 by a single radio. "Thus, the OFDM signal radiated from the OFDM signal generation device 10a into the spatial transmission path is received and decoded by the OFDM signal decoding device 20a, and the operation for decoding is performed based on

the demodulated output of the FFT 25a that operates in synchronization with the IFFT 14a." Ex.1008, [0021]. A POSITA would understand that this as describing receiving the first and second channels B1 and B2 by a single decoding device 20a.

206. Mori also states that "user C is in a situation where communication is performed by setting three of the remaining B1, B2, B4" among channels B1 through B8, and describes "multi-carrier signals for communication using B1, B2." Ex.1008, [0074]-[0075]. A POSITA would understand the wireless signal for channel bonded and gap-filled adjacent channels B1 and B2 to be transmitted to a single radio for user C. Mori describes the "transmission signal from this generation device [10 of Fig. 1] is supplied to an antenna 19 and radiated into the spatial transmission path from that antenna." Ex.1008, [0045].

207. At the receiver, Mori describes the "transmission signal supplied to the spatial transmission path is received by an antenna 21 and supplied to … the multi-carrier signal decoding device 20 … composed of a downconverter (D/C) 22, a BPF 23, an orthogonal demodulation circuit 24, an FFT (Fast Fourier Transform; fast Fourier transform) 25, a carrier demapping circuit 26, a parallel-serial conversion circuit 27, and an information signal output terminal 29." Ex.1008, [0046]. The receiver is illustrated as a single chain radio in Fig. 3, which is reproduced below.

【図２】



Ex.1007, Fig. 2. A POSITA would recognize that the OFDM symbols for channels B1 and B2 (and B4) are received by the radio for user C.

208. Gardner observes that, "[t]o transmit the modulated data, the transmitter either uses a separate antenna for each data stream or coherently combines the modulated data streams prior to transmission via fewer antennas than there are data streams (such as a single antenna for a combination of all data streams)." Ex.1006, 3:12-17.

209. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses transmitting channel bonded and gap filled channels B1 and B2 via a single spatial transmission path to the radio for user C.

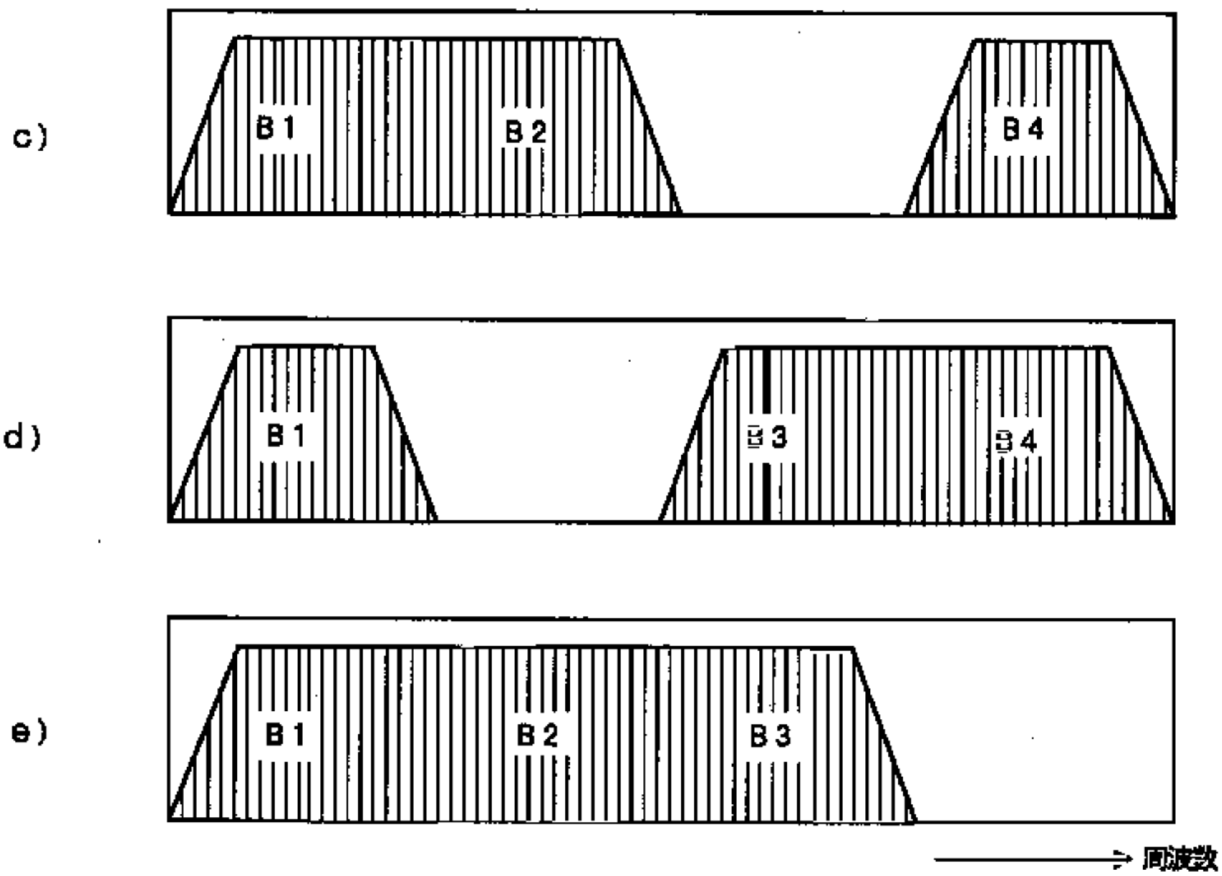
210. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

j. Claim [6.0] extensible to additional channels

Claim	Limitations
[6.0]	The method of claim 1, wherein the method is extensible to additional channels

211. As discussed above, Mori depicts and describes channel bonding and gap filling of three channels B1, B2, and B3, "since bands B1 to B3 are used consecutively, consecutive multi-carrier signals are arranged in bands B1 to B3." Ex.1008, [0122]. The use of channel bonding and gap filling with three consecutive channels B1, B2 and B3 is depicted in Fig. 8(e) of Mori, which is reproduced below.

【図8】



Ex.1007, Figs. 8(c)-(e). Mori states that "data may be allocated to 10 subcarriers each between B1 and B2 and between B2 and B3, totaling 20 subcarriers, resulting in an increase in transmission rate." Ex.1008, [0126]. Mori further states that, "when communication is conducted using four consecutive bands, data allocation may be made to a total of 30 subcarriers, resulting in an increase in transmission rate." Ex.1008, [0127].

212. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses extension of channel bonding and gap filling to more than two adjacent channels.

213. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

k. Claim [7.0] eliminating synthesizer frequency popping

Claim	Limitations
[7.0]	7. The method of claim 1, further comprising eliminating synthesizer frequency popping during bandwidth switching between packets

214. A POSITA would understand elimination of synthesizer frequency popping during bandwidth switching to be accomplished when dual-chain signal processing operate with two parallel IFFTs that remain tuned to legacy channel centers. The '326 Patent states that "[a]n embodiment of the present invention is directed to increasing the data rate even more without increasing the analog and mixed signal requirements. This may be accomplished by using a full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)." Ex.1001, 10:48-53.

215. The ‘326 Patent describes Fig. 7 as “a block diagram illustrating one physical implementation of a dual-chain wideband radio having low pass filters (LPFs), ADCs, and Fast Fourier Transforms (FFTs). This is a ‘multiple radios in a box’ implementation. In this implementation multi-chain radios, each with a single bandwidth and multiple FFTs, multiple converters, and multiple analog filters are used. This is a form of ‘channel bonding’ and may use common synthesizer and automatic gain control (AGC) with receiving.” Ex.1001, 12:9-17. An advantage described in the ‘326 Patent for the dual-chain embodiment is that “no synthesizer frequency-popping exists when bandwidth switching between packets. Synthesizers may stay tuned to legacy channel centers for most or at all times.” Ex.1001, 4:50-54, see also 16:22-26 (“an embodiment of a dual-chain wideband transmitter,” which has “[n]o synthesizer pop when switching between normal and wide packets”). Therefore a POSITA would understand “synthesizer frequency popping during bandwidth switching between packets” is eliminated through use of separate IFFTs that stay tuned to legacy channel centers for each channel.

216. Gardner discloses use of separate “OFDM modulators 221, 222, which may be implemented using standard components, [and] perform[] OFDM modulation using an inverse fast Fourier transform (IFFT), thereby providing a time-domain signal suitable for feeding to” antennas 110a, 110b. Ex.1006, 8:1-5, see also Figs. 2A-2B and 4.

217. Mori describes "simultaneously generating the subcarrier signals provided to the two or more unit communication bands," using a 256-point IFFT "performing 64-point IFFT operations simultaneously" on four channels, and that "modulation signals for the four bands … are generated simultaneously by the aforementioned IFFT." Ex.1008, [0066], [0071].

218. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses four parallel 64-point IFFTs that each remain tuned to legacy channel centers even when generating signals for channel bonded and gap-filled adjacent channels B1 and B2.

219. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

l. Claim [8.0] tuning a first synthesizer to the first channel

Claim	Limitations
[8.0]	8. The method of claim 1 further comprising: tuning a first synthesizer to the first channel, wherein the first synthesizer remains tuned to the first channel during mode switching; and

220. As discussed above, the '326 Patent describes "using a full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)" with dual chain "'multiple radios in a box'" design in which "multi-

chain radios, each with a single bandwidth and multiple FFTs" "use common synthesizer" frequencies without bandwidth switching by "stay[ing] tuned to legacy channel centers." Ex.1001, 4:50-54, 10:48-53, 12:9-17.

221. As also discussed above, Gardner discloses use of separate "OFDM modulators 221, 222, which may be implemented using standard components, [and] perform[] OFDM modulation using an inverse fast Fourier transform (IFFT), thereby providing a time-domain signal suitable for feeding to" antennas 110a, 110b. Ex.1006, 8:1-5, see also Figs. 2A-2B and 4.

222. Mori describes "simultaneously generating the subcarrier signals provided to the two or more unit communication bands," using a 256-point IFFT "performing 64-point IFFT operations simultaneously" on four channels, and that "modulation signals for the four bands … are generated simultaneously by the aforementioned IFFT." Ex.1008, [0066], [0071]. A 64-point IFFT for channel B1 is performed on inputs 127 to 191 of the 256-point IFFT in Fig. 3, and a 64-point IFFT for channel B2 is performed on inputs 192 to 255.

223. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses four parallel 64-point IFFTs that each remain tuned to legacy channel centers even when generating signals for channel bonded and gap-filled adjacent channels B1 and B2, with a first of the 64-point IFFTs remaining tuned to channel B1 (inputs 127 to 191 of the 256-point IFFT in Fig. 3) regardless

of whether channel bonding and gap-filling with adjacent channel B2 is being performed.

224. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

m. Claim [8.1] tuning a second synthesizer to the second channel

Claim	Limitations
[8.1]	tuning a second synthesizer to the second channel, wherein the second synthesizer remains tuned to the second channel during mode switching

225. See the preceding discussion regarding claim [8.0].

226. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses four parallel 64-point IFFTs that each remain tuned to legacy channel centers even when generating signals for channel bonded and gap-filled adjacent channels B1 and B2, with a second of the 64-point IFFTs remaining tuned to channel B2 (inputs 192 to 255 of the 256-point IFFT in Fig. 3) regardless of whether channel bonding and gap-filling with adjacent channel B1 (or adjacent channel B3) is being performed.

227. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

n. Claim [9.0] use of common synthesizers

Claim	Limitations
[9.0]	9. The method of claim 1, wherein channel bonding comprises use of common synthesizers

228. A POSITA would understand that use of the "full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)" with dual chain "'multiple radios in a box'" design including "multi-chain radios, each with a single bandwidth and multiple FFTs" results in "use [of] common synthesizer" frequencies without bandwidth switching by "stay[ing] tuned to legacy channel centers." Ex.1001, 4:50-54, 10:48-53, 12:9-17. That is, the IFFT frequency synthesis is "common" to both using adjacent channels individually and using the same adjacent channels with channel bonding and gap filling, without switching center frequencies.

229. As discussed above, Gardner discloses use of separate "OFDM modulators 221, 222, which may be implemented using standard components, [and] perform[] OFDM modulation using an inverse fast Fourier transform (IFFT), thereby providing a time-domain signal suitable for feeding to" antennas 110a, 110b. Ex.1006, 8:1-5, see also Figs. 2A-2B and 4.

230. Mori describes "simultaneously generating the subcarrier signals provided to the two or more unit communication bands," using a 256-point IFFT "performing

64-point IFFT operations simultaneously" on four channels, and that "modulation signals for the four bands … are generated simultaneously by the aforementioned IFFT." Ex.1008, [0066], [0071].

231. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses four parallel 64-point IFFTs that are "common synthesizers" each remaining tuned to legacy channel centers regardless of whether when generating signals for adjacent channels B1 and B2 individually or for channel bonded and gap-filled adjacent channels B1 and B2. A first of the 64-point IFFTs will remain tuned to channel B1 (inputs 127 to 191 of the 256-point IFFT in Fig. 3) and a second of the 64-point IFFTs remaining tuned to channel B2 (inputs 192 to 255 of the 256-point IFFT in Fig. 3) regardless of whether channel bonding and gap-filling with adjacent channels B1and B2 is being performed.

232. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

o. Claim [10.0] OFDM subcarriers

Claim	Limitations
[10.0]	10. The method of claim 1, wherein the plurality of data subcarriers are OFDM subcarriers

233. Gardner discloses OFDM subcarriers. Ex.1006, 8:1-19, 8:44-47, 9:38-67, 10:18-21.

234. Mori likewise discloses "an OFDM signal with a subcarrier frequency interval of 312.5 kHz." Ex.1008, [0012], see also [0002], [0011], [0020], [0021].

235. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses that the subcarriers or channel bonded and gap-filled adjacent channels B1 and B2 are OFDM subcarriers.

236. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

p. Claim [11.0] additional points

Claim	Limitations
[11.1]	11. The method of claim 10, further comprising: identifying additional points in a Fast Fourier Transform (FFT) across the first and second channels; and

237. As discussed in §III.G.9, a POSITA would understand (FFT/IFFT) points to refer to subcarriers used during the transformation from the time domain to the frequency domain or vice versa. The '326 Patent describes "the inventive fil[l]ed-gap OFDM approach" as involving "the use of additional subcarriers to 'fill the gap' between the two single channels 2 and 3 to permit greater information over the bandwidth." Ex.1001, 10:12-16, see also Fig. 4 ("Case 2"). A POSITA would understand "identifying additional points in a Fast Fourier Transform (FFT) across

the first and second channels" to relate to subcarriers in the guard band(s) between adjacent channels.

238. In IEEE 802.11, channels are 20 MHz with subcarriers spaced at 312.5 KHz, for a total of 64 subcarriers. However, conventionally only the center 52 subcarriers within a channel are used, for data or pilot signals. The remaining subcarriers within each channel are not used, to form half of a guard band between two adjacent channels and, after transformation from the frequency domain to the time domain, a guard interval for each OFDM symbol. Therefore, in IEEE 802.11 systems "additional" subcarriers (or IFFT "points") exist on the outer edge of the first channel or the second channel, near the channel boundary .

239. Conventionally the subcarriers within those channel edge regions are left unused, for guard bands. During transformation from the frequency domain to the time domain by a 64-point IFFT, unused or "null" subcarriers in the guard band correspond to a time domain guard interval $T_{GUARD} = T_{GI}$ as depicted on the right side of Fig. 22 in the '326 Patent, which is reproduced below.

$$w_T(t) = \begin{cases} \sin^2\left(\frac{\pi}{2}(0.5 + t/T_{TR})\right) & (-T_{TR}/2 < t < T_{TR}/2) \\ 1 & (T_{TR}/2 \le t < T - T_{TR}/2) \\ \sin^2\left(\frac{\pi}{2}(0.5 - (t-T)/T_{TR})\right) & (T - T_{TR}/2 \le t < T + T_{TR}/2) \end{cases}$$

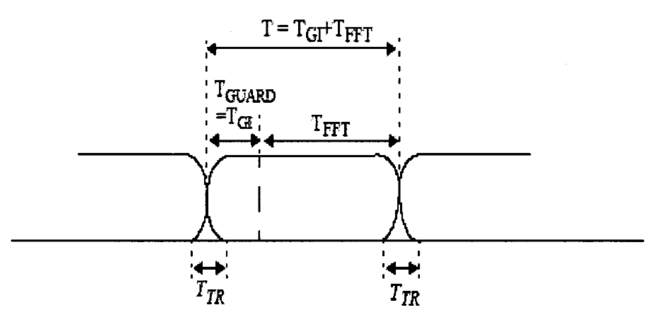


FIGURE 22

Ex.1001, Fig. 20. The center 52 subcarriers within a channel, conventionally used for data or pilot signals, correspond to T_{FFT} in Fig. 22. Whether used for data or the guard band, the subcarriers (or IFFT points) intrinsically exist on the edges of an IEEE 802.11 channel.

240. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. Whether used for a guard band or to carry data, the edge subcarriers ("additional points") are present in the 64-point IFFTs of Mori.

241. The '326 Patent describes "filling the gap" between adjacent channels, normally used for the guard band, with data subcarriers. The result is that more of the 64 subcarriers (and the corresponding points for the 64-point IFFT) carry data.

242. Mori states that a guard band is formed with a 64-point IFFT by "the signal levels of inputs…, which correspond to the frequencies at both ends of the transmission frequency band, [being] set to 0, suppressing the frequency spectrum components at the boundaries of adjacent frequency channels, thereby forming a guard band." Ex.1008, [0008], [0010]. A POSITA would understand that the inputs for the guard band subcarriers ("additional points") across channels B1 and B2 are already provided to a 64-point IFFT in Mori, with the corresponding input terminals receiving a null signal when the guard band is provided and data signals when the guard band subcarriers are used to carry data.

243. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses that "additional points" in the 64-point IFFTs correspond to channel edge (guard band) subcarriers for channels B1 and B2.

244. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

q. Claim [11.1] adding subcarriers to the additional points

Claim	Limitations
[11.1]	adding subcarriers to the additional points

245. A POSITA would recognize that the channel structure in IEEE 802.11 systems comprises, for each 20MHz channel, 64 subcarriers equally spaced (in the frequency domain), separated by 312.5KHz, such that subcarriers intrinsically exist on channel edges. However, as discussed above, those subcarriers are normally left unused to form part of a guard band between adjacent channels.

246. To the extent that adding ***data*** subcarriers to an IEEE 802.11 channel is considered, Mori states that "data allocation may be made for 10 subcarriers at 10 input terminals" to produce an "increase in transmission rate due to the increase in subcarriers" by "the addition of 10 subcarriers in the guard band area." Ex.1008, [0124]-[0125]. Mori also states that, "because subcarrier signals [to be] inserted between bands B1 and B2 are generated, data allocation may be made for 10

subcarriers at 10 input terminals … among input terminals 187 to 197" of the 256-point IFFT processor. Ex.1008, [0124]. A POSITA would recognize that input terminals 187 to 197, labeled "Null" in Fig. 3, correspond to guard band "subcarriers #+32 to #+27" for one channel (e.g., channel B1, associated with "Bi" in Mori) and guard band "subcarriers … #−27 to #−31" for an adjacent channel (e.g., channel B2, associated with Bi+1 in Mori), which correspond to a guard band between the two channels when gap-filling is not used. See Ex.1008, [0113]-[0115].

247. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses adding data subcarriers to the "additional points" in the 64-point IFFTs that correspond to guard band subcarriers for channels B1 and B2.

248. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

r. Claim [12.0] additional points on an outer edge

Claim	Limitations
[12.0]	12. The method of claim 11, wherein the additional points exist on an outer edge of the first channel or the second channel

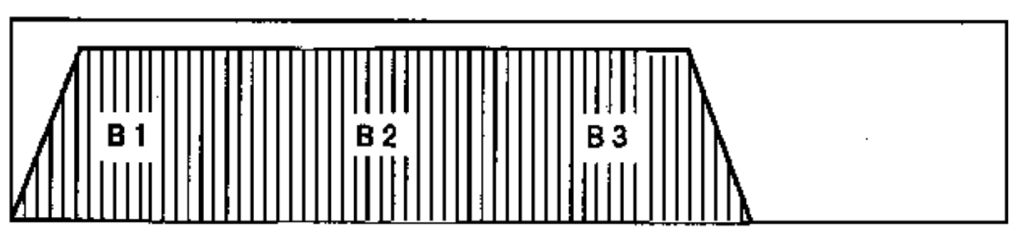
249. A POSITA would note that the guard band subcarriers between adjacent first and second channels correspond to "additional points" on an outer edge of the first channel and on an outer edge of the second channel. Mori states that "data allocation may be made for 10 subcarriers at 10 input terminals" to produce an "increase in

transmission rate due to the increase in subcarriers" by "the addition of 10 subcarriers in the guard band area" between adjacent channels B1 and B2. Ex.1008, [0124]-[0125]. A POSITA would recognize a first portion of those "10 subcarriers in the guard band area" between adjacent channels B1 and B2 correspond "additional points … on an outer edge of the first channel" while a second portion of the "10 subcarriers in the guard band area" between adjacent channels B1 and B2 correspond "additional points exist[ing] on an outer edge of the first channel" B1 "additional points exist[ing] on an outer edge of … the second channel" B2.

250. To the extent that outer edges of the combined channels are also considered, as discussed above in connection with claim [6.0], Mori depicts and describes channel bonding and gap filling of three channels B1, B2, and B3, "since bands B1 to B3 are used consecutively, consecutive multi-carrier signals are arranged in bands B1 to B3." Ex.1008, [0122]. Mori states that "data may be allocated to 10 subcarriers each between B1 and B2 and between B2 and B3, totaling 20 subcarriers, resulting in an increase in transmission rate."

【図8】

e)



EX.1007, Fig. 8(e); Ex.1008, [0126]. A POSITA would understand Fig. 8(e) of Mori to depict

Mori further states that, "when communication is conducted using four consecutive bands, data allocation may be made to a total of 30 subcarriers, resulting in an increase in transmission rate." Mori, Ex.1008, [0127]. A POSITA would recognize that when four consecutive channels B1, B2, B3, and B4 are channel bonded and gap-filled as described by Mori, data subcarriers are allocated to "additional points" on outer edges of the center two channels B2 and B, combined.

251. Further, Mori teaches that, by using the 256-point IFFT processor of Fig. 3 to simultaneously perform 64-point IFFT operations on multiple channels, "there is no need to provide … guard bands" "because the OFDM signals of multiple bands generated by a single IFFT are orthogonal to each other, and thus do not interfere with one another." Ex. 1008, [0117]. "Even when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for the omission of guard bands." Ex. 1008, [0118]. A POSITA would understand these statements to suggest that guard bands are not required at either edge of channel B1 or B2, or at edges of the channel bonded and gap-filled channels B1 and B2, combined.

252. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses adding data subcarriers to guard band regions for channels B1 and B2. Because Mori teaches that guard bands may be omitted when "when [separate, 64-point] IFFTs are … synchronized to operate at the same symbol period," a POSITA would be motivated to include data subcarriers in guard band regions at outer edges of the combined, channel bonded and gap-filled channels B1 and B2.

253. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

s. Claims [13.0] guard band on each edge is filled

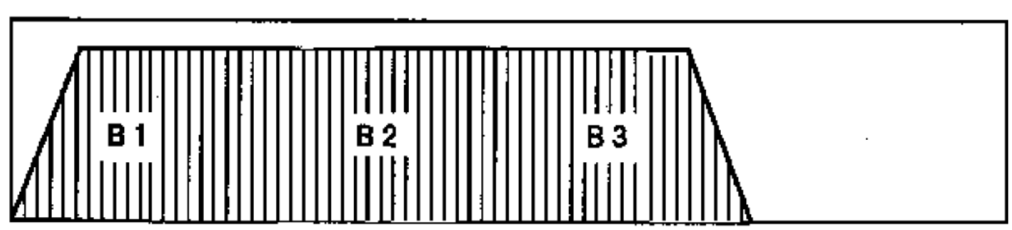
Claim	Limitations
[13.0]	The method of claim 12, wherein a guard band on each edge is filled with data

254. See the above discussion regarding claim [12.0].

255. Mori discloses filling both edges of channel B2 with data subcarriers "when three consecutive [channels] B1, B2, and B3" are used:

【図8】

e)



EX.1007, Fig. 8(e); Ex.1008, [0126].

256. Furthermore, Mori describes communicating on "four consecutive bands" B1 through B4 with "data allocation … to a total of 30 subcarriers" for the intervening guard bands, "using an IFFT that may generate OFDM signals for four bands." Ex.1008, [0127], [0136]. Mori teaches that "there is no need to provide…guard bands" with "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four" channels B1 through B4, because "the OFDM signals of [the four channels] generated by a single IFFT are orthogonal to each other, and thus do not interfere with one another." EX.1008, ¶¶[0066],[0117]. "Even when the OFDM signals that are orthogonal among multiple bands are generated using multiple[, separate 64-point] IFFTs, when those IFFTs are…synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for the omission of guard bands." EX.1008, ¶ [0118].

257. A POSITA would recognize that Mori suggests filling all channel edge subcarriers (guard bands) for any channel with data, to increase transmission rates, when either a single IFFT uses all subcarriers for that channel and adjacent channels or multiple IFFTs using the subcarriers of individual channels are "synchronized to operate at the same symbol period." In that case, "guard bands on each edge," either of individual channels or of groups of channel bonded and gap-filled channels, would be "filled with data."

258. Further, a POSITA would recognize that Gardner, when combined with Mori as described above, discloses adding data subcarriers to guard band regions for channels B1 and B2. Because Mori teaches that guard bands may be omitted "when [separate, 64-point] IFFTs are … synchronized to operate at the same symbol period," a POSITA would be motivated to include data subcarriers in guard band regions at outer edges of the combined, channel bonded and gap-filled channels B1 and B2.

259. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

t. Claims [14.0] anti-aliasing

Claim	Limitations
[14.0]	14. The method of claim 1, further comprising utilizing an anti-aliasing technique at a receiver

260. As discussed in §III.G.10, a POSITA would understand anti-aliasing to refer to use of low-pass filters to prevent aliasing artifacts when converting analog signals to digital format.

261. The '326 Patent describes "the undesired impact of analog-to-digital converter (ADC) sample-rate aliasing. ADC sample-rate aliasing may occur when a wide signal is received by multiple, parallel receive chains designed to receive a single narrow signal." Ex.1001, 14:17-21. According to the '326 Patent, sample-rate

aliasing results from “filter leakage associated with a radio processing one half of a signal while receiving both halves of the signal.” Ex.1001, 14:26-28. The ‘326 Patent describes aliasing as “especially an issue when using the filled-gap technique” “when two radios are used in parallel to separately process half of the wideband signal (lower and upper halves).” Ex.1001, 14:37-40.

262. The ‘326 Patent describes a “low pass filter on the receiver side” as an “anti-alias technique.” For example, the ‘326 Patent depicts and describes alternatives including a “low pass filter on half of the wideband receiver” and a “low pass filter on both the upper and lower halves of the wideband receiver.” Ex.1001, 6:45-49, Figs. 34-35. “[T]he invention concern[s] adaptive anti-aliasing techniques and implementations” to “eliminate[] aliasing due to adjacent channel waveform[s].” Ex. 1001, 14:4-7. In particular, “the invention concerns filter leakage associated with a radio processing one half of a signal while receiving both halves of the signal.” Ex. 1001, 14:26-28. A POSITA would therefore understand low pass filtering to be one basic form of “anti-alias technique.”

263. “The invention allows for the interfering half of the signal to be applied to subtract, or otherwise cross-compare, with the non-interfering half of the signal to remove the distortion associated with filter leakage. The magnitude of the interference is a function of the front end filter. For example, the subcarrier from the upper half of the signal may come through (leak) when processing the lower half of

the signal by the FFT. This is a receiver side design issue associated with wideband radio using the dual-chain implementation, i.e., when two radios are used in parallel to separately process half of the wideband signal (lower and upper halves). This is especially an issue when using the filled-gap technique." Ex. 1001, 14:28-40.

264. The '326 Patent describes "adaptive anti-aliasing techniques" matching performance to receiver design, describing different forms as providing anti-aliasing either as better suited for a given receiver design or as providing superior anti-aliasing. At the most basic level, for example, the '326 Patent teaches that separate "6th order low pass filter[s] … with normal Q factors" for each radio chain is sufficient "in a dual-chain wideband radio," while "12th order low pass filter … with a double Q factor" may be required "on the receiver side in a single chain wideband radio." Ex. 1001, Figs. 11-12, 12:30-34.

265. The '326 Patent also teaches that more complex designs may provide superior anti-aliasing. For instance, the '326 Patent suggests "a 6th order Butterworth low pass filter on both the upper and lower halves of the wideband receiver." Ex. 1001, Fig. 35, 14:47-49. Progressively more sophisticated anti-aliasing is described in various embodiments, up to and including various coherent "alias canceling … in the time domain (Pre-FFT …) and with frequency offset present or not" and "frequency domain adaptive non-coherent anti-alias restore technique[s]." Ex. 1001, 16:64-17:3

266. Based on the various embodiments described in the ‘326 Patent, viewed as a whole, a POSITA would understand the ‘326 Patent to describe low pass filters as a basic anti-aliasing technique.

267. Mori teaches that “the generation device and decoding device can be configured with only one system of IFFT or FFT and filter corresponding to a number of points that is multiple times the unit communication bandwidth, enabling the transmission or reception of signals for multiple unit communication bands.” Ex.1008, [0143]. The receiver (decoding device 20) in Mori includes a bandpass filter (BPF 23) in which “the signal components of the frequency bandwidth necessary for demodulation are frequency-selected.” Ex.1008, [0088], see also [0016] (“the frequency band signal necessary for demodulation [is] selected and extracted by a BPF 23”). Like a low pass filter, a bandpass filter filters frequencies higher than the frequencies of interest. Therefore a POSITA would understand Mori’s bandpass filter 23, which is more frequency-selective than a low pass filter, to comprise an anti-aliasing technique at a receiver.

268. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses using a bandpass filter to “frequency-select[]” “the signal components of the frequency bandwidth necessary for demodulation,” providing an anti-aliasing technique.

269. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

u. Claims [15.0] passing upper signals and lower signals through a first filter and a second filter

Claim	Limitations
[15.0]	15. The method of claim 14, wherein the anti-aliasing technique comprises passing upper signals and lower signals through a first filter and a second filter

270. Mori teaches that the purpose of that bandpass filter 23 is to "select[] and extract[]" "the frequency band signal necessary for demodulation." Ex.1008, [0016].

271. The output of the bandpass filter 23 is passed to "orthogonal demodulation circuit 24," in which "the supplied signal is IQ demodulated to obtain the I and Q component signals, and the obtained signal is converted into a digital signal by an A/D converter that is not illustrated, and the converted I and Q signals are supplied to a 64-point FFT circuit 25a" "that operates in synchronization with the IFFT 14a." Ex.1008, [0017], [0021].

272. In decoding channel bonded and gap-filled adjacent channels B1 and B2, Mori teaches that FFT circuit 25a should "perform[] FFT operations on the supplied subcarrier signals with a degree of at least twice" "a predetermined number N (where N is a natural number) of subcarriers." Ex.1008, [0041], see also [0043] ("performing FFT operations on the subcarrier signals supplied to the multiple unit

communication bands with a degree of at least twice N to obtain calculation results”).

273. In a specific embodiment, Mori states that the “FFT 25 in the multi-carrier signal decoding device 20 has an input terminal for 256 time-domains corresponding to the IFFT illustrated in FIG. 3, … and 256 point FFT operations are performed to generate output signals of the 256 frequency domains by performing FFT operations on the signals supplied to the terminal.” Ex.1008, [0083]. A POSITA would understand these teachings to mean that the 256-point FFT simultaneously performs four 64-point FFTs, analogous to the 256-point IFFT processor of Fig. 3.

274. Mori also describes “simultaneously decoding the subcarrier signals supplied to multiple unit communication bands…with at least: a first step (25) of performing FFT operations on the supplied subcarrier signals …, and a second step (26) of obtaining a decoded signal related to the subcarrier signals supplied simultaneously from the operation results obtained through FFT operations in the first step.” Ex.1008, [0041]. Mori further states that “the multi-carrier signal composed of subcarrier signals of multiple blocks is simultaneously demodulated in the FFT 25, the demodulated signals of multiple blocks obtained through demodulation are simultaneously decoded.” Ex.1008, [0060]. A POSITA would understand this to describe to describe separate demodulator/decoder chains for each channel B1 through B2 supplied to the 256-point FFT 25.

275. Since the purpose of bandpass filter 23 is to "select[] and extract[]" "the frequency band signal necessary for demodulation" before time domain to frequency domain conversion, and since the 256-point FFT simultaneously performs four 64-point FFTs, a POSITA would be motivated to implement a separate bandpass filter for each channel on which the 256-point FFT operates, to "select[] and extract[]" "the frequency band signal" for the demodulator/decoder chains for each channel B1 through B4. That is, a POSITA would be motivated to use a first bandpass filter the demodulator/decoder chain for channel B1, a second bandpass filter the demodulator/decoder chain for channel B2, a third bandpass filter the demodulator/decoder chain for channel B3, and a fourth bandpass filter the demodulator/decoder chain for channel B4, each tuned to the respective channel. A POSITA would have a reasonable expectation of success in implementing separate bandpass filters for each channel received by the 256 point FFT in Mori, tuned to the respective channel B1, B2, B3, or B4. This would have been a combination of known elements with predictable results.

276. A POSITA would recognize that Gardner, when combined with Mori as described above, suggests using a first bandpass filter to "frequency-select[]" "the signal components of the frequency bandwidth" for channel B1 of channel bonded and gap-filled adjacent channels B1 and B2, and using a second bandpass filter to

"frequency-select[]" "the signal components of the frequency bandwidth" for channel B2 of channel bonded and gap-filled adjacent channels B1 and B2.

277. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

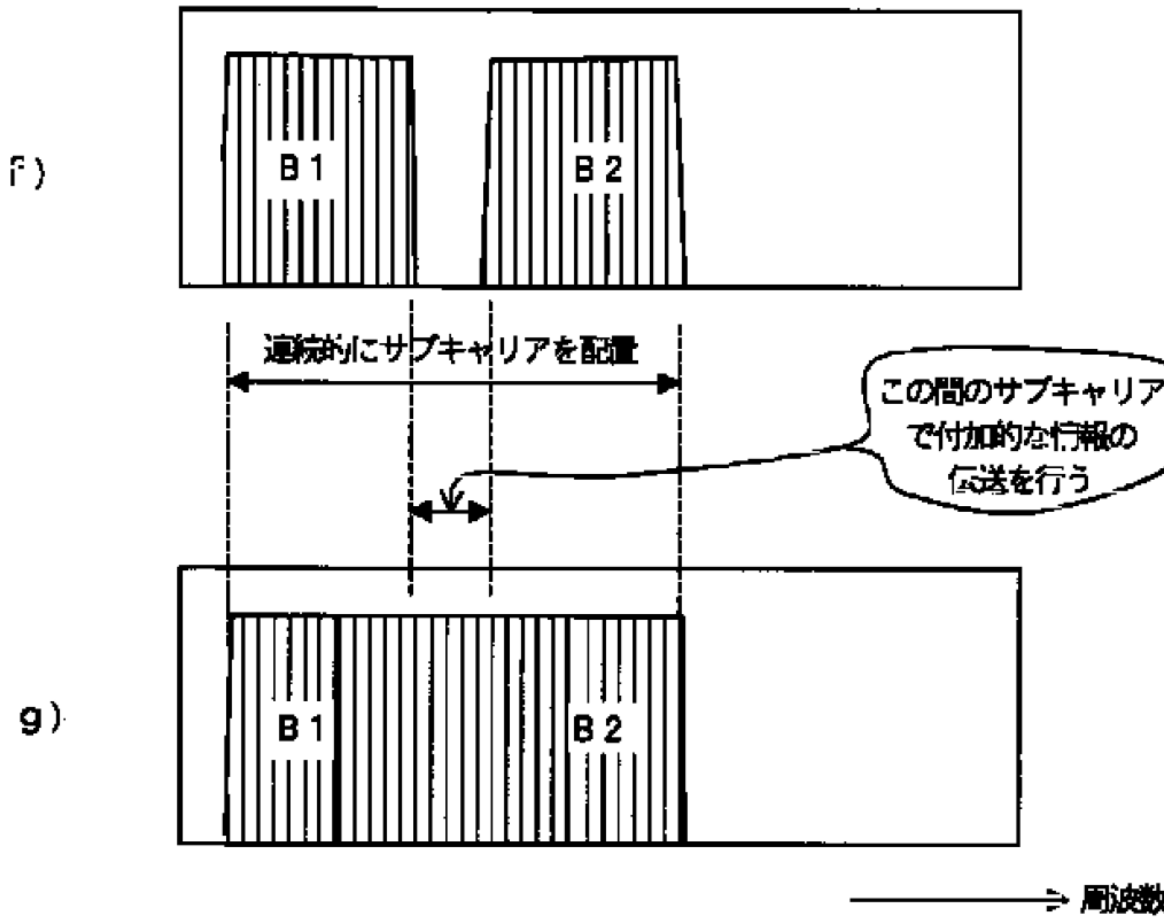
v. Claims [17.0] frequency gap is filled

Claim	Limitations
[17.0]	17. The system of claim 16, wherein the frequency gap is filled with a portion of the first plurality of subcarriers and a portion of the second plurality of subcarriers

278. See the discussion of claim [16.2] in §III.H.2.c.

279. As discussed above, Mori discloses the "addition of 10 subcarriers in the guard band area" between adjacent channels B1 and B2 to "increase the number of data carriers by allocating subcarrier data to the guard band between the consecutive bands B1 and B2" and obtain an "increase the number of multi-carriers compared to when guard bands are provided, resulting in a larger transmission rate." Ex.1008, [0123], [0125]. Mori depicts the additional data subcarriers as filling the guard band between channels B1 and B2 in Fig. 9(g), which is reproduced (together with Fig. 9(f)) below.

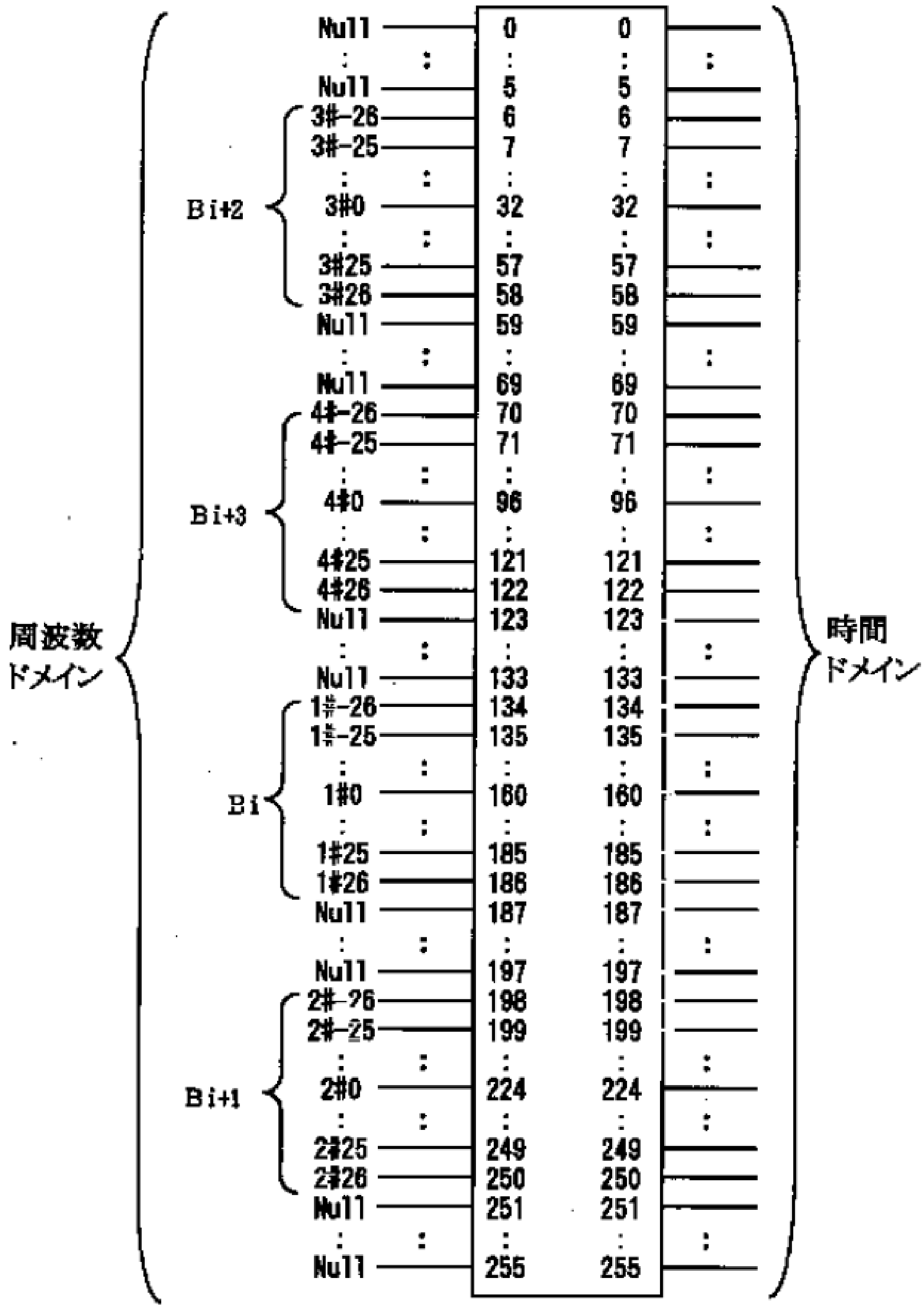
【図9】



Ex.1007, Figs. 9(f)-(g). “In this way, the area of the guard band may be effectively utilized.” Ex.1008, [0131].

280. Mori teaches that the additional 10 data subcarriers are input “at 10 input terminals … among input terminals 187 to 197.” Ex.1008, [0124]. Those input terminals are depicted in Fig. 3, which is reproduced below.

【図３】


Null
Null
3#-26
3#-25
3#0
3#25
3#26
Null
Null
4#-26
4#-25
4#0
4#25
4#26
Null
Null
1#-26
1#-25
1#0
1#25
1#26
Null
Null
2#-26
2#-25
2#0
2#25
2#26
Null
Null
Bi+2
Bi+3
Bi
Bi+1
周波数
ドメイン
時間
ドメイン
0 5 6 7 32 57 58 59 69 70 71 96 121 122 123 133 134 135 160 185 186 187 197 198 199 224 249 250 251 255

Ex.1007, Fig. 3. A POSITA would recognize that a first portion of input terminals 187 to 197 correspond to subcarriers in a guard band region at an edge of channel Bi (B1), and a second portion of input terminals 187 to 197 correspond to subcarriers in a guard band region at an edge of channel Bi+1 (B2).

281. A POSITA would recognize that Gardner, when combined with Mori as described above, discloses using a portion of subcarriers for channel B1 and a portion of subcarriers for channel B2 to fill the guard band between channels B1 and B2 with data subcarriers.

282. For at least these reasons, Gardner as combined with Mori renders these elements obvious.

I. Gardner, Mori, and either or both of Bolinth or Williams

283. Bolinth and Williams describe different approaches to using guard band subcarriers for data. Bolinth relates to filter, while Williams describes using repeated data. These two approaches are distinct and can be used independently or together.

1. Motivation to Combine Bolinth with Gardner and Mori

284. There are multiple motivations for a POSITA to make such a combination and reasons to believe it would be successful. The motivations for combining Mori with Gardner are discussed above in §III.H.1.

285. Gardner, Mori, and Bolinth are all concerned with improving bandwidth, thus their purposes are aligned. Gardner and Bolinth discuss improving data

rates/bandwidth in IEEE 802.11 systems, while Mori addresses the related goal of improving frequency utilization efficiency in an IEEE 802.11-like system.

286. Furthermore, Gardner, Mori, and Bolinth all use known technologies such as OFDM, making their technologies compatible for combining. Since all three patents have related goals, their combination is attractive to a POSITA.

287. As discussed above, Gardner describes use of "a MIMO system" in which "all network components … have additional RF chains and antennas" (i.e., using multiple radios at the transmitter and receiver) to improve data rates through spatial diversity. Mori describes a complementary system improving data rates for a single "spatial transmission path" through channel bonding and gap filling.

288. Bolinth describes a technique complementary to and improving use of guard band subcarriers to carry data as described by Mori. Bolinth describes "[f]iltering the sub-carriers in the edge area of an OFDM symbol" so that the number of the unused sub-carriers at the edge of the OFDM symbol) [may] be reduced" and "a comparatively higher data rate can be achieved." Ex.1009, [0014]. Bolinth and Mori share the objective of increasing data rate through use of guard band subcarriers to carry data.

289. Bolinth's filtering of channel edge subcarriers to carry data is a refinement of Mori's use of guard band data subcarriers, can improve the combination of channel bonding and guard band filling described in Mori, and is complementary to the non-

generate MIMO system described in Gardner in the same way discussed above for Mori.

290. By leveraging the advantages of Bolinth in a system using the combination of Gardner and Mori described above, a POSITA would reasonably expect to achieve better bandwidth/data rates. Moreover, the reduction of inter-channel interference would improve the functionality of either Gardner or Mori, even without regard to the implication in Bolinth that guard band subcarriers are used to carry data. The plurality of transmitted streams in the non-degenerate MIMO system of Gardner would benefit from reduction of inter-channel interference as taught by Bolinth. Mori's goal of limiting bandwidth waste by using guard band subcarriers to carry data would also benefit from that reduction of inter-channel interference. A POSITA would have found it advantageous to combine Bolinth with Gardner and Mori, individually or in combination.

291. It would have been routine to a POSITA to add the edge subcarrier filtering of Bolinth to the systems of Gardner and Mori. This would have been a combination of known elements with predictable results.

2. Motivation to Combine Williams with Gardner and Mori

292. There are multiple motivations for a POSITA to make such a combination and reasons to believe it would be successful. The motivations for combining Mori with Gardner are discussed above in §III.H.1.

293. Like Gardner and Mori, Williams describes IEEE 802.11/IEEE 802.11-like systems with the same channel structures. As discussed above, Gardner and Mori disclose complementary approaches improvement of IEEE 802.11-like systems.

294. Gardner, Mori, and Williams all relate to OFDM use of a plurality of carrier frequencies to transmit large amounts of data in wireless LANs. The technologies of all three patents are therefore compatible.

295. Mori describes channel bonding and the addition of guard band data subcarriers, without specifying what data is inserted into the guard band. Mori merely suggests that, among other things, "the increase in subcarriers … may be used to transmit additional information, such as adding error correction codes … which may ultimately increase the transmission rate by correcting the resulting error signals." Ex.1008, [0129]. Mori does not suggest a specific form for the error correction codes.

296. Williams describes filling the guard band with repeated data, replicated from one end of the data on the remaining subcarriers—specifically, filling the guard band with a duplicate of the last (25%) segment of the data being transmitted in the channel. A POSITA would understand that the repeated data allows for error correction at the receiver, potentially improving data rates by reducing the number of OFDM symbol retransmissions needed. Mori does not require transmission of non-repeated data in the guard band, and concedes that an unspecified form of error

correction code may be carried on the guard band subcarriers. The repeated data of Williams therefore presents a POSITA with one specific option for selecting data for guard band data subcarriers of Mori. A POSITA would have found it advantageous to combine Williams with Mori, individually or with a combination of Gardner and Mori.

297. It would have been routine to a POSITA to employ William's repeated data as Mori's error correction codes in a system combining Gardner and Mori. This would have been a combination of known elements with predictable results.

3. Claim Analysis

298. In the following sub-sections, I provide a claim-by-claim analysis of Gardner as combined with Mori and either of Bolinth or Williams as disclosing the claim limitations of the '326 Patent. This would have been a combination of known elements with predictable results.

a. Claims [12.0] additional points on an outer edge

Claim	Limitations
[12.0]	The method of claim 11, wherein the additional points exist on an outer edge of the first channel or the second channel

299. See the discussion of "additional points" in connection with claim [11.0] within §III.H.2.p.

300. Mori teaches "the addition of 10 subcarriers in the guard band area" between adjacent channels B1 and B2 using a 256-point IFFT. A POSITA would understand that half of those additional data subcarriers correspond to edge subcarriers of channel B1 and half to edge subcarriers of channel B2. Mori also describes a multi-user system for users A, B, and C. Ex.1008, [0074].

301. Bolinth teaches that "[f]iltering the sub-carriers in the edge area of an OFDM symbol also allows the guard band (i.e., the number of the unused sub-carriers at the edge of the OFDM symbol) to be reduced so that, in addition, a comparatively higher data rate can be achieved" despite inter-channel interference in a multi-user system. Ex.1009, [0014], see also [0003]-[0004], [0010]-[0011]. As noted above, a POSITA would understand the description of reducing the number of "unused" subcarriers in the guard band in order to achieve a higher data rate to indicate that some of the guard band subcarriers are used to carry data. See §III.D. As discussed in that section, a POSITA would therefore understand Bolinth to describe performing concurrent IFFTs on adjacent channels with oversampling and filtering of guard bands subcarriers on the channel edges.

302. Mori teaches that, when "OFDM signals of multiple bands generated by a single [256 point] IFFT are orthogonal to each other, and thus do not interfere with one another," such that "there is no need to provide such guard bands." Ex.1008, [0117]. "Even when the OFDM signals that are orthogonal among multiple bands

are generated using multiple IFFTs, when those IFFTs are…synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for the omission of guard bands." EX.1008, [0118]. "Therefore, communication of multi-carrier signals using multiple consecutive bands does not require suppression of the signal components in the guard band areas between the consecutive bands." EX.1008, [0119]. Mori suggests eliminating guard bands and using the subcarriers for data.

303. In a specific example within Mori, channel "B3 … is already used by user A, … while user C is in a situation where communication is performed by … the remaining B1, B2, B4 … bandwidths." Ex.1008, [0074]. A POSITA would recognize that use of channel B3 by user A and contiguous channels B1 and B2 by user C in Mori is analogous to the circumstance of User A being allocated subcarriers 0 through L and User B being allocated subcarriers L+1 through N−1.

304. Accordingly, a POSITA would be motivated to apply the filtering of Bolinth to at least the guard band subcarriers between channels B4 and B5, to allow those subcarriers to be used for data as suggested by Bolinth. The filtering of Bolinth could be combined with the bandpass filter 23 in Mori, to filter (outer) edge subcarriers as taught by Bolinth for Mori's channel bonded, gap-filled channels B1 and B2 when all guard bands are omitted as suggested by Mori. The teaching in Mori that allocating data to guard band subcarriers increases transmission rates would further

motivate a POSITA to make this combination. This would have been a combination of known elements with predictable results.

305. Those guard band subcarriers ("additional points") exist on an outer edge of channel B4, relative to adjacent channel B5. When implementing edge subcarrier filtering in combination with bandpass filtering for channels B4 and B5, a POSITA would be motivated to implement the same combination for all channels, to obtain the benefits described in Bolinth for each of channels B1 through B8 in Mori.

306. A POSITA would recognize that Gardner, when combined with Mori and Bolinth as described above, discloses using guard band subcarriers an outer edge of one channel, relative to an adjacent channel, to carry data by filtering the guard band subcarriers.

307. Alternatively, Mori suggests that, in adding data subcarriers to the guard band between channels, "the increase in [data] subcarriers … may be used to transmit additional information, such as adding error correction codes … which may ultimately increase the transmission rate by correcting the resulting error signals." Ex.1008, [0129]. Mori does not suggest a specific form for the error correction codes.

308. Williams describes "generation of the guard bands that contain repeated data" by "replicat[ing] a percentage of the data at one end of the [data stream] and places that percentage at the other end," within the guard band. Ex.1011, [0008]. Williams

teaches that this is permitted by the IEEE 802.11a standard. Ex.1011, [0007]. A POSITA would recognize the repeated data as a form of error correction, allowing comparison of the repeated data segments for identifying and correcting differences.

309. A POSITA would recognize that Gardner, when combined with Mori and Williams as described above, discloses using guard band subcarriers on outer edges of channel bonded and gap-filled adjacent channels B1 and B2 to carry a repeated portion of the data within the remaining channel subcarriers. A POSITA would recognize that Gardner, when combined with Mori and Williams as described above, discloses filling the guard band on the edge of channel B1 with repeated data for channel B1—on an "outer" edge of the combined channels B1 and B2 (that is, the edge of channel B1 furthest from channel B2). This would have been a combination of known elements with predictable results.

310. For at least these reasons, Gardner as combined with Mori and either or both of Bolinth or Williams renders these elements obvious.

b. Claims [13.0] guard band on each edge is filled

Claim	Limitations
[13.0]	The method of claim 12, wherein a guard band on each edge is filled with data

311. See the discussion of claim [12.0] within §III.I.3.a.

312. Bolinth teaches that, despite inter-channel interference in a multi-user system, "the guard band (i.e., the number of the unused sub-carriers at the edge of the OFDM symbol)" may be "reduced so that … a comparatively higher data rate can be achieved." Ex.1009, [0014].

313. Mori teaches that "[e]ven when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for the omission of guard bands." Ex. 1008, [0118]. Mori discloses a 256-point IFFTs processor for simultaneously calculating four 64-point IFFTs. Mori describes allocating data to guard band subcarriers to increase transmission rates. Ex.1008, [0124]-[0127].

314. Accordingly, a POSITA would be motivated to fill all guard bands with data, relying on the filtering described in Bolinth and the 256-point IFFTs processor of Mori to reduce errors.

315. A POSITA would be motivated to applying the filtering of Bolinth to all guard band subcarriers in order to increase transmission rates as taught by Mori. This would have been a combination of known elements with predictable results.

316. Alternatively, Williams describes "combat[ting] [inter-symbol interference (ISI)]" by "generation of the guard bands that contain repeated data" by "replicat[ing] a percentage of the data at one end of the [data stream] and places that

percentage at the other end," within the guard band. Ex.1011, [0006]-[0008]. Williams teaches that this is permitted by the IEEE 802.11a standard. Ex.1011, [0007]. A POSITA would recognize that the repeated data is provided for error correction.

317. Mori suggests that "the increase in [data] subcarriers … may be used to transmit additional information, such as adding error correction codes … which may ultimately increase the transmission rate by correcting the resulting error signals." Ex.1008, [0129].

318. A POSITA would be motivated to transmit repeated data as taught by Williams in all guard band subcarriers in order to provide error correction as taught by Mori. This would have been a combination of known elements with predictable results.

319. A POSITA would recognize that Gardner, when combined with Mori and Williams as described above, discloses filling the guard band on each edge of channel B1 with repeated data, using repeated for channel B1 on the edge of channel B1 furthest from channel B2 and repeated data for channel B2 on the edge of channel B1 closest to channel B2 (and repeated data for channel B3 on the edge of channel B2 closest to channel B3). This would have been a combination of known elements with predictable results.

320. For at least these reasons, Gardner as combined with Mori and either or both of Bolinth or Williams renders these elements obvious.

J. Mori and Lu and Williams

1. Motivation to Combine Mori, Lu and Williams

321. There are multiple motivations for a POSITA to make such a combination and reasons to believe it would be successful. The motivations for combining Williams with Mori are discussed above in §III.I.2.

322. Both Mori and Lu are concerned with improving data transfer in wireless communications Ex.1008, [0001] ("accommodate a wide range of transmission speeds by flexibly managing communication bandwidth and [with] good channel utilization"), Ex.1010, [0001] ("pre-existing wireless standards may limit the data transfer rate between devices").

323. Both Mori and Lu describe, either explicitly or implicitly, the concept of channel bonding—that is, "simultaneously transmit[ting] data . . . over two adjacent channels as if it were a single channel with twice the bandwidth." Ex.1007, Fig.9(f), Ex.1008, [0121] ("a continuous multi-carrier signal is arranged between adjacent bands B1 and B2"), Ex.1010, [0026].

324. Both Mori and Lu disclose or suggest using a portion of the guard band for additional data subcarriers. Ex.1008, [0119] ("there is no need to suppress the signal components in the guard band portions that exist between the consecutive bands, so [data] subcarrier signals that are in a synchronous relationship are placed there"),

Ex.1008, [0026] (“the interval guard may be shortened from 800 ns to 400 ns when a data rate of 140 Mbps is used”).

325. Both Mori and Lu describe or suggest the use of MIMO (spatial diversity) in combination with channel bonding. Ex.1008, [0016] (“a spatial transmission path”). Ex.1010, [0026].

326. Mori, Lu, and Williams all disclose use of OFDM on a plurality of carrier frequencies to transmit large amounts of data in wireless LANs. Mori and Lu both disclose use of QAM. Mori and Williams explicitly disclose using FFTs/IFFTs and, although Lu does not explicitly describe such functions, FFTs/IFFTs are practical implementations of the Discrete Fourier Transform used by OFDM. These commonalities between the technologies of Mori, Lu, and Williams render their respective teachings compatible, and any combination would yield predictable results and have an expectation of succeeding.

327. Mori uses IEEE 802.11-like channels, while Lu addresses compatibility between IEEE 802.11a/g and IEEE 802.11n devices. That is, Lu describes multi-protocol communication while Mori describes generating and decoding a multicarrier signal. A POSITA would readily understand the nexus between these two goals, and the complementary nature of the respective teachings. Analogous to Mori and Lu, Williams describes improving IEEE 802.11/IEEE 802.11-like systems.

328. A POSITA would have found it advantageous to combine Mori, Lu, and Williams, to enable compatibility of different IEEE 802.11-type systems while improving transmission rates through a combination of channel bonding, gap-filling, and MIMO. It would have been routine to add the features of Lu and Williams to the system of Mori. A POSITA would have a reasonable expectation of success in making such combination.

2. Claim Analysis

329. In the following sub-sections, I provide a claim-by-claim analysis of Mori as combined with Lu and Williams disclosing the claim limitations of the '326 Patent. This would have been a combination of known elements with predictable results.

a. Claims [1.0], [16.0], [18.0]: Preambles

Claim	Limitations
[1.0]	A method for increasing data rates and data throughput in a network
[16.0]	A system for increasing data rates and data throughput in a network
[18.0]	A non-transitory computer-readable medium having instructions stored thereon

330. Mori discloses a "method of utilizing a guard band between those unit communication bands for communication [that] increases frequency utilization

efficiency and can further enhance the transmission speed of the information signals." Ex.1008, [0141].

331. Mori also discloses "a high-speed, large-capacity communication system" "using a predetermined number N of subcarriers having an IFFT 14 capable of simultaneously generating at least twice the number of subcarriers as N." Ex.1008, Abstract.

332. A POSITA would understand that one of the benefits of "increase[d] frequency utilization efficiency and … enhance[d] transmission speed of the information signals" as taught by Mori result from increasing data rates and data throughput, and that "high-speed, large-capacity communication" as disclosed by Mori comprises increased data rates and data throughput.

333. Mori discloses "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori necessarily employs hardware containing memory storing software instructions.

334. Lu describes "methods [that] provide information (e.g., data transfer rate, amount of data) in each wireless data packet." Ex.1010, [0013]. A POSITA would

understand Lu to be discussing data rates and data throughput, and improvements thereto.

335. Lu is directed to a “system … in a network.” Lu, Ex.1010, [0015]. As noted above, Lu describes “provid[ing] information (e.g., data transfer rate, amount of data) in each wireless data packet.” Ex.1010, [0013]. A POSITA would understand Lu to be discussing data rates and data throughput, and improvements thereto.

336. Lu relates to “devices [that] communicate [using] a wireless protocol (i.e., standard) … defin[ing] hardware and software parameters such that the devices are able to send, receive, and interpret data.” A POSITA would recognize that Lu describes hardware containing memory storing software instructions.

337. Williams is concerned with the “reduction of the overall data transfer rate of the communications system” resulting from inter-symbol interference between OFDM symbols.” Ex.1011, [0002], [0006].

338. Williams is directed to a “system … in a network.” Ex.1011, [0036]. As also noted above, Williams is concerned with the “reduction of the overall data transfer rate of the communications system” resulting from inter-symbol interference between OFDM symbols.” Ex.1011, [0002], [0006].

339. Williams describes “us[ing] existing data generating hardware and software.” A POSITA would recognize that Williams describes hardware containing memory storing software instructions.

340. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

b. Claims [1.1], [16.1], [18.1]: selecting at least a first channel and a second channel

Claim	Limitations
[1.1]	selecting at least a first channel and a second channel, wherein the first channel and the second channel are adjacent without any other channels therebetween, wherein the first channel and the second channel each have a plurality of data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and second channels
[16.1]	means for selecting at least a first channel and a second channel, wherein the first channel is adjacent to the second channel without any other channels therebetween, wherein the first channel comprises a first plurality of subcarriers, and the second channel comprises a second plurality of subcarriers, wherein a frequency gap corresponding to at least one guard band between the first channel and the second channel separates the first plurality of subcarriers from the second plurality of subcarriers
[18.1]	instructions to select at least a first channel and a second channel, wherein the first channel and the second channel are adjacent without any other channels therebetween, wherein the first channel and the second channel each have a plurality of

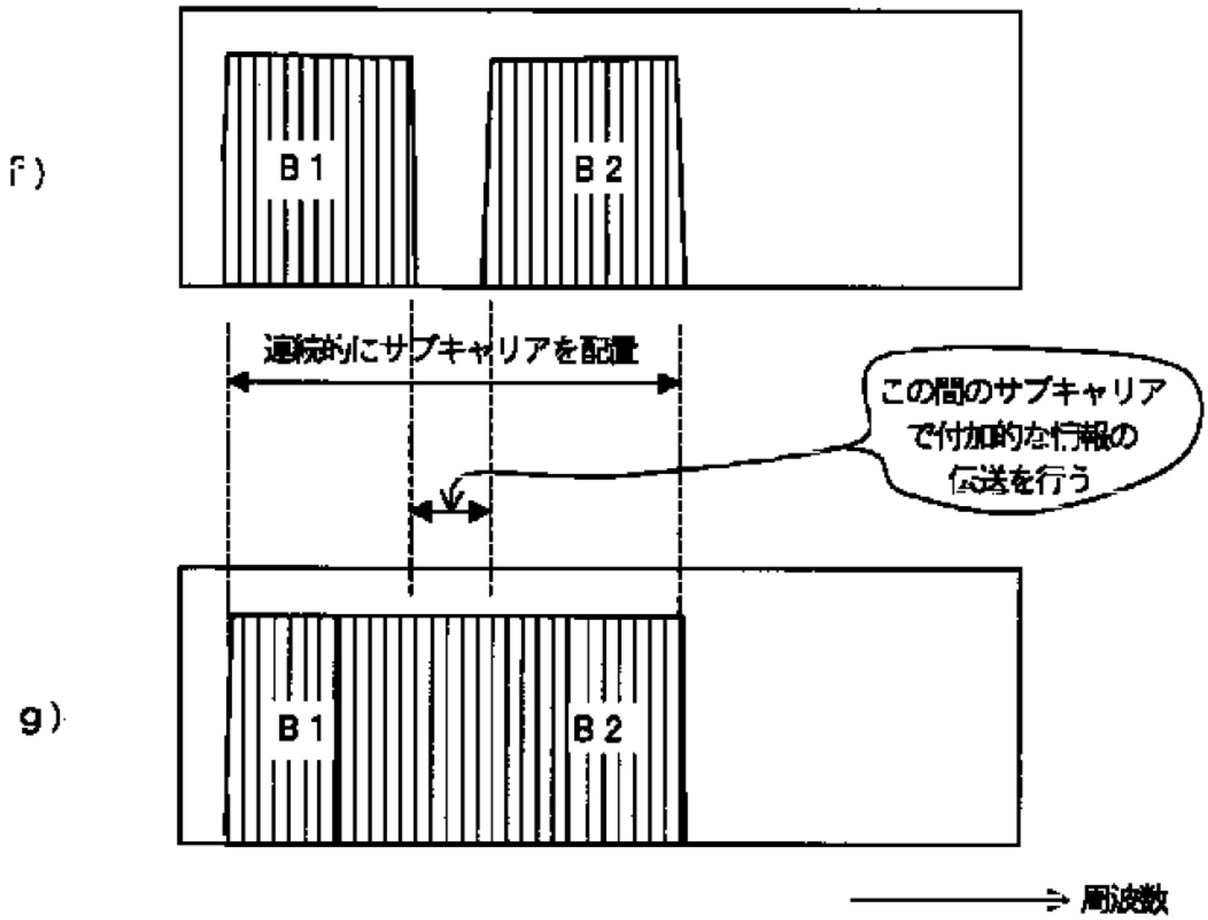
	data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and second channels

341. Mori discloses using IEEE 802.11a-type channels: "The practical wireless access system uses a bandwidth of 100 MHz in the 5 GHz band, with four channels spaced 20 MHz apart, and communication is conducted through each channel" in which "the transmission method used is OFDM" and "the spacing between each carrier is set to 312.5 kHz." Mori, Ex.1008, [0003]-[0005].

342. In a specific example, Mori states that "user C is in a situation where communication is performed by setting three of the remaining B1, B2, B4" among channels B1 through B8, and describes "multi-carrier signals for communication using B1, B2." Ex.1008, [0074]-[0075].

343. Mori depicts and explicitly describes "adjacent bands B1 and B2." Ex.1008, [0121]. While describing Fig. 8(c), a POSITA would recognize that the statement also describes Figs. 9(f)-(g), which are reproduced below:

【図9】



Ex.1007, Figs. 9(f)-(g); see also Fig. 8(c). A POSITA would recognize that, in Fig. 9(f) of Mori, “the first channel [B1] and the second channel [B2] are adjacent without any other channels therebetween,” and that “the first channel [B1] and the second channel [B2] each have a plurality of data subcarriers.” Figs. 9(f)-(g) and the associated description of Mori implicitly disclose “selecting” adjacent channels B1 and B2.

344. Because Mori states that Fig. 9(f) "illustrates an arrangement of subcarriers having conventional guard bands" (Ex.1008, [0128]), a POSITA would recognize that "the data subcarriers of the first channel [B1] and the data subcarriers of the second channel [B2] are separated by a frequency gap corresponding to one or more guard bands between the first and second channels" [B1] and [B2].

345. Lu describes maintaining compatibility between "a first wireless protocol (e.g., 802.11a, 802.11g)" and "a second wireless protocol (e.g., 802.11n)." Ex.1010, [0015]. For the second wireless protocol, Lu describes use of a "channel bonding mechanism [that] may simultaneously transmit data frames over two adjacent channels as if it were a single channel with twice the bandwidth." Ex.1010, [0026]. A POSITA would recognize from "adjacenty channels" that the channels are adjacent, without any other channels therebetween.

346. Because the first and second wireless protocols in Lu are IEEE 802.11-based (having the same channel structure), a POSITA would understand that the channels in Lu each comprise a plurality of subcarriers. Lu describes a "guard interval." Ex.101, [0026]. A POSITA would understand that that "guard interval" corresponds to a frequency gap (at least one guard band) separating the subcarriers of one channel from the subcarriers of the other channel.

347. In the context of maintaining compatibility between "a first wireless protocol (e.g., 802.11a, 802.11g)" and "a second wireless protocol (e.g., 802.11n)," Lu

describes “a MIMO (Multiple Input Multiple Output) indication bit, wherein a ‘0’ value indicates STTD (Space-Time Transmit Diversity) and a ‘1’ value indicates VLST (Vertical Layered Space Time) diversity.” Ex.1010, [0026]. This is separate from the “channel bonding indicator bit” also described in Lu. Ex.1010, [0026]. A POSITA would understand that MIMO and channel bonding are distinct approaches and may be employed either separately or together.

348. Mori describes an OFDM signal that is “radiated from an antenna 19 into a spatial transmission path,” from which “the signal radiated into the spatial transmission path is received by an antenna 21.” Ex.1008, [0014]-[0016]. A POSITA would recognize that the spatial transmission path of Mori may be one of multiple spatial transmission paths in a MIMO system of the type referenced by Lu.

349. As discussed in §III.G.12, A POSITA would understand that spatial multiplexing through MIMO increases data rate by sending independent data streams from each transmitting antenna.

350. A POSITA would be motivated to employ MIMO and channel bonding, each disclosed by Lu, together in order to obtain the known benefits of those distinct techniques. For channel bonding, a POSITA would be motivated to select the “adjacent bands B1 and B2” as taught by Mori, for one spatial transmission path from antenna 19 to antenna 21 in Mori, among multiple spatial transmission paths resulting from use of MIMO.

351. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2. Mori therefore discloses a "means for selecting at least a first channel and a second channel."

352. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori discloses "instructions to select at least a first channel and a second channel."

353. Lu discloses device 102 that includes a transceiver 104 and "implement[s] a first wireless protocol (e.g., 802.11a, 802.11g)" and devices 110A, 110B that each include a respective a transceiver 112A, 112B and that "implement a second wireless protocol (e.g., 802.11n)." Ex.1010, [0015]. The "devices that use the first protocol … communicate with devices that use the second protocol and vice versa." Ex.1010, [0014]. A POSITA would recognize that Lu discloses "means for selecting at least a first channel and a second channel" for devices using channel bonding according to the second wireless protocol.

354. Lu relates to "devices [that] communicate [using] a wireless protocol (i.e., standard) … defin[ing] hardware and software parameters such that the devices are able to send, receive, and interpret data." A POSITA would recognize that Lu discloses "instructions to select at least a first channel and a second channel" within devices using channel bonding according to the second wireless protocol.

355. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

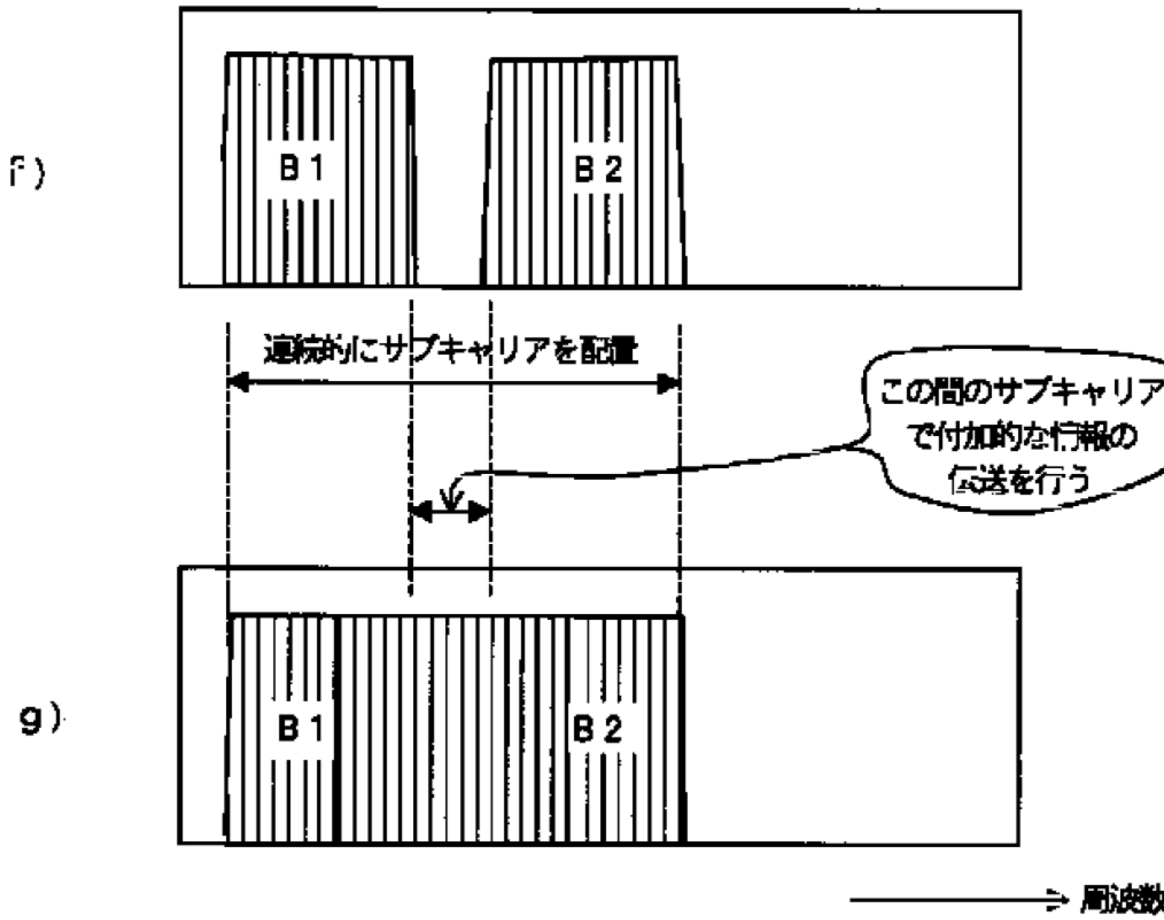
c. Claims [1.2], [16.2], [18.2]: partially filling the frequency gap with data subcarrier[s]

Claim	Limitations
[1.2]	partially filling the frequency gap between the first channel and the second channel by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform
[16.2]	means for partially filling the frequency gap with at least one additional subcarrier such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform
[18.1]	instructions to partially fill the frequency gap between the first channel and the second channel by adding one or more data

	subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform

356. Mori discloses "continuously arranging multi-carrier signals … to increase the number of multi-carriers compared to when guard bands are provided, resulting in a larger transmission rate." Ex.1008, [0123]. Embodiments of Mori achieve an "increase in transmission rate due to the increase in subcarriers" by "the addition of 10 subcarriers in the guard band area." Ex.1008, [0125]. Mori graphically depicts "a case where subcarriers are arranged consecutively in consecutive bands" by "addition of 10 subcarriers in the guard band area" to "increase the number of data carriers by allocating subcarrier data to the guard band between the consecutive bands B1 and B2" to obtain an "increase the number of multi-carriers compared to when guard bands are provided, resulting in a larger transmission rate." Ex.1008, [0123], [0125], [0128], [0132]. These statements describe Figs. 9(f)-(g) of Mori, which are reproduced below.

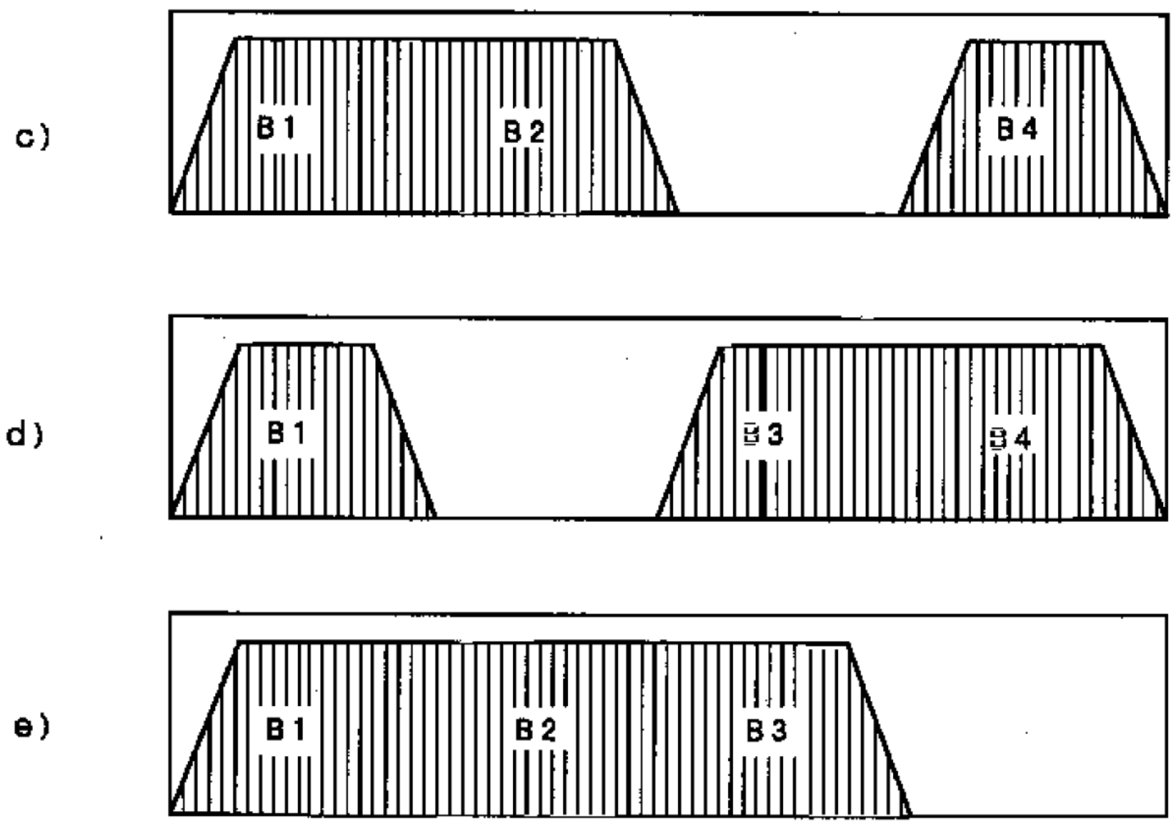
【図9】



Ex.1007, Figs. 9(f)-(g). "In this way, the area of the guard band may be effectively utilized." Ex.1008, [0131].

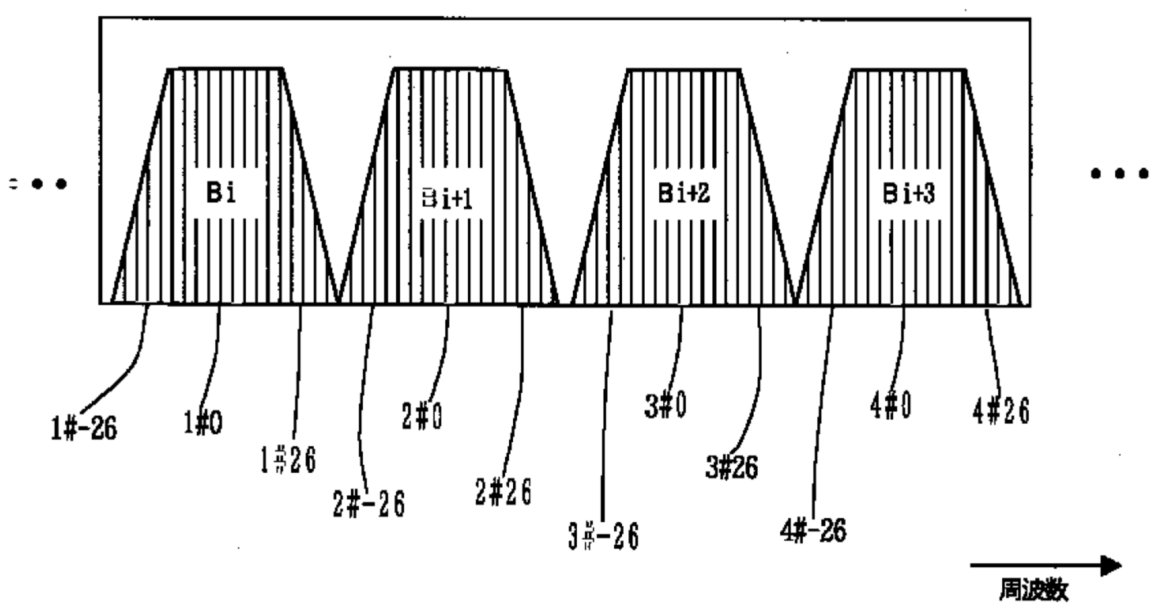
357. Mori discloses other examples of using the guard band(s) between adjacent channels to carry data. For instance, Figs. 8(c)-(e) of Mori are reproduced below:

【図8】



Ex.1007, Figs. 8(c)-(e). Mori states that these figures illustrate "state where subcarriers are arranged consecutively in bands that are used continuously", with Fig. 8(c) illustrating "signals using three bands B1, B2, and B4, where consecutive multi-carrier signals are arranged between the adjacent bands B1 and B2," Fig. 8(d) illustrating "consecutive multi-carrier signals are arranged between the consecutive bands B3 and B4," and Fig. 8(e) illustrating that, "since bands B1 to B3 are used consecutively, consecutive multi-carrier signals are arranged in bands B1 to B3." Ex. 1008, [0120]-[0122]. By contrast, Fig. 4 of Mori illustrates, for four consecutive bands, "the frequency band and the positions of the subcarrier frequencies within that band." Ex.1008, [0069]. Fig. 4 of Mori is reproduced below.

【図4】



Ex.1007, Fig. 4. A POSITA would recognize that the channel labeled "Bi" in Fig. 4 corresponds to channel B1 in Figs. 8(c)-(e) and 9(f)-(g), the channel labeled "Bi+1" in Fig. 4 corresponds to channel B2 in Figs. 8(c)-(e) and 9(f)-(g), The channel labeled "Bi+2" in Fig. 4 corresponds to channel B3 in Figs. 8(c)-(e), and the channel labeled "Bi+3" in Fig. 4 corresponds to channel B1 in Figs. 8(c)-(e).

358. A POSITA would therefore understand that Fig. 8(c) illustrates channels B1 and B2 with the guard band therebetween filled with data subcarriers (similar to Fig. 9(g), Fig. 8(d) similarly illustrates channels B3 and B4 with the guard band therebetween filled with data subcarriers, and Fig. 8(e) illustrates channels B1, B2, and B3 with two guard bands filled with data subcarriers.

359. Mori therefore discloses "[at least partially] filling the frequency gap between the first channel [B1] and the second channel [B2] by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers." To the extent the '326 Patent requires the frequency gap to be partially rather than completely filled, it would be obvious to a POSITA to modify the teachings of Mori such that a frequency gap is only partially filled with data subcarriers.

360. As discussed above, a POSITA would understand "using full spectral synthesis capability of a fast Fourier transform or an inverse fast Fourier transform" to be satisfied by use of an IFFT on all subcarriers of a channel, including the subcarriers within the frequency gap corresponding to a guard band. The '326 Patent describes "using a full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)" as "achieved, for example, by 1) using two existing legacy circuits or radios in parallel (2-64 point FFTs that process two halves of the signal (1-upper and 1-lower)) or 2) by using a single circuit that

processes the whole signal (1-128 point FFT)." Ex.1001, 10:51-52, 11:23-27. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. A POSITA would recognize that each 64-point IFFT operation uses all channel subcarriers of a channel, including the subcarriers within the frequency gap corresponding to a guard band.

361. In the context of maintaining compatibility between "a first wireless protocol (e.g., 802.11a, 802.11g)" and "a second wireless protocol (e.g., 802.11n)," Lu describes "a channel bonding indicator bit, wherein a '1' value indicates that a channel bonding mechanism is used" with "one such channel bonding mechanism … simultaneously transmit[ting] data frames over two adjacent channels as if it were a single channel with twice the bandwidth" and "a shortened guard interval indicator bit, wherein a '1' value [that] indicates a shortened guard interval has been used (e.g., the interval guard may be shortened from 800 ns to 400 ns when a data rate of 140 Mbps is used)." Ex.1010, [0026]. A POSITA would understand the "shortened guard interval" combined with "when a data rate of 140 [megabits per second (Mbps)]" to indicate that guard band subcarriers are used for data. As conceded in the '326 Patent, "the highest data rate for 802.11a/g is 54 Mbps." Ex.1001, 4:26-27. Channel bonding alone only results in 108 Mbps, at most. Ex.1001, 10:29-30 ("108 Mbps ((96 sc)/(48 sc)=2× data rate factor; 2 times 48 data subcarriers (sc)=96 data sc")).

Using guard band subcarriers for data, however, can produce data rates higher than 108 Mbps without increasing constellation density or coding rate. Ex.1001, 10:32-37 ("an increase in data rate to 121.5 Mbps ((108 sc)/(48 sc)=2.25× data rate yielding 121.5 Mbps, where 64(left channel)+64(right channel)−6(left guard)−5(right guard)−4(pilot tones)−5(lost to DC offsets)=108 data subcarriers)"), 10:44-47 ("increase the data rate to 135 Mbps, for example, dual channel with all gaps filled yields a data rate of 135 Mbps ((120 sc)/(48 sc)=2.5× times 54 Mbps=135 Mbps; 64+64−4−4=120 data subcarriers)"). A POSITA would also understand channel bonding and a shortened guard interval to be distinct but compatible, suitable for use either separately or together.

362. A POSITA would be motivated to employ channel bonding and a shortened guard interval, each disclosed by Lu, together in order to obtain the known benefits of those distinct techniques. In implementing both channel bonding and a shortened guard interval as described by Lu, a POSITA would recognize the channel bonded and gap-filled adjacent bands B1 and B2 of Mori as an example of the two techniques in combination, and would use that approach so that "the area of the guard band may be effectively utilized" as taught by Mori. Ex.1008, [0131]. This would be a combination of known elements with predictable results.

363. In addition, Mori describes channel bonding and the addition of guard band data subcarriers, without specifying what data is inserted into the guard band. Mori

merely suggests that, among other things, "the increase in subcarriers … may be used to transmit additional information, such as adding error correction codes … which may ultimately increase the transmission rate by correcting the resulting error signals." Ex.1008, [0129]. Mori does not suggest a specific form for the error correction codes.

364. Williams describes filling the guard band with repeated data, replicated from one end of the data on the remaining subcarriers—specifically, filling the guard band with a duplicate of the last (25%) segment of the data being transmitted in the channel. Ex.1011, [0008]. A POSITA would understand that the repeated data allows for error correction at the receiver, potentially improving data rates by reducing the number of OFDM symbol retransmissions needed. Mori does not require transmission of non-repeated data in the guard band, and concedes that an unspecified form of error correction code may be carried on the guard band subcarriers. The repeated data of Williams therefore presents a POSITA with one specific option for selecting data for guard band data subcarriers of Mori and Lu. A POSITA would have found it advantageous to combine Williams with Mori, individually or with a combination of Mori and Lu.

365. A POSITA would be motivated to employ both channel bonding as disclosed by Mori and Lu, with guard band data subcarriers as disclosed by Mori and Williams and suggested by Lu, in order to obtain the cumulative benefits described for those

techniques, individually. For channel bonding, a POSITA would be motivated to select the "adjacent bands B1 and B2" as taught by Mori, setting the channel bonding indicator as described by Lu. For gap filling, a POSITA would be motivated to select error correction codes as described by Mori in the form of repeated data as described by Williams, setting the shortened guard interval bit as described by Lu.

366. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2. Mori therefore discloses a "means for filling the frequency gap" between adjacent channels with "data subcarrier[s]."

367. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori discloses "instructions to fill the frequency gap" between adjacent channels with "data subcarrier[s]."

368. Lu discloses device 102 that includes a physical (PHY) layer 108 and "implement[s] a first wireless protocol (e.g., 802.11a, 802.11g)" and devices 110A, 110B that each include a respective PHY layer 116A, 116B and that "implement a second wireless protocol (e.g., 802.11n)." Ex.1010, [0015]. The "devices that use the first protocol … communicate with devices that use the second protocol and vice versa." Ex.1010, [0014]. The channel bonding indicator and the shortened guard interval indicator are transmitted by the PHY layer(s) 116A and 116B. A POSITA would recognize that Lu discloses "means for filling the frequency gap" between adjacent channels with "data subcarrier[s]."

369. Lu relates to "devices [that] communicate [using] a wireless protocol (i.e., standard) … defin[ing] hardware and software parameters such that the devices are able to send, receive, and interpret data." A POSITA would recognize that Lu discloses "instructions to fill the frequency gap" between adjacent channels with "data subcarrier[s]" within devices 110A, 110B using the channel bonding indicator and the shortened guard band indicator according to the second wireless protocol.

370. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

d. Claims [1.3], [16.3], [18.3]: combining channels using channel bonding with OFDM

Claim	Limitations

[1.3]	combining the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)
[16.3]	means for combining the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)
[18.3]	instructions to combine the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM)

371. As discussed above, a POSITA would understand "channel bonding with orthogonal frequency division multiplexing (OFDM)" to be satisfied by use of IFFTs operating separately on each channel. The '326 Patent describes use of "multi-chain radios each with a single bandwidth and multiple FFTs, multiple converters, and multiple analog filters" as "a form of 'channel bonding'." Ex.1001, 12:13-15.

372. Mori also discloses using OFDM, stating that "each channel has a unit communication bandwidth of 20 MHz, enabling transmission at 20 Mbps or more. The transmission method used is the OFDM method, which is resistant to multipath interference caused by waves reflected by buildings, walls, etc., and has high frequency utilization efficiency." Ex.1008, [0005].

373. In a specific example of channel bonding and gap filling between channels B1 and B2, Mori depicts and describes "the addition of 10 subcarriers in the guard band

area" between those two channels. Ex.1007, Fig. 9, Ex.1008, [0125]. Mori also depicts and describes "a 256-point IFFT processor performing 64-point IFFT operations simultaneously" on the four consecutive channels B1, B2, B3, and B4. Ex.1007, Fig. 3, Ex.1008, [0066]. Mori teaches that, by using the 256-point IFFT processor of Fig. 3 to simultaneously perform 64-point IFFT operations on multiple channels, "the OFDM signals of multiple bands generated by a single IFFT are orthogonal to each other, and thus do not interfere with one another." Ex. 1008, [0117]. "Even when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal." Ex. 1008, [0118].

374. Lu describes the second wireless protocol as using channel bonding for communications between devices 110A, 110B both implementing the second wireless protocol. Lu also explicitly describes use of OFDM for at least portions of header 302 and header extension 304 for data frames of wireless signals according to the second wireless protocol by the PHY layers 116A, 116B of those devices 110A, 110B. Ex.1010, Fig. 3, [0024]-[0025]. A POSITA would understand Lu to disclose channel bonding with OFDM.

375. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15,

a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2, and the 256-point IFFT processor of Fig. 3 simultaneously performs 64-point IFFT operations on multiple channels. Mori therefore discloses a "means for combining" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)."

376. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. A POSITA would recognize that Mori discloses "instructions to combine" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)."

377. Lu describes OFDM symbols within the header 302 and header extension 304 of data frames of wireless signals generated by the PHY layers 116A, 116B of devices 110A, 110B implementing the second wireless protocol. Mori explicitly discloses one or more IFFT calculators generating OFDM symbols for the two channels using all 64 subcarriers for each channel. A POSITA would recognize that Lu, when combined with Mori as described above, discloses a "means for

combining" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)."

378. Lu relates to "devices [that] communicate [using] a wireless protocol (i.e., standard) … defin[ing] hardware and software parameters such that the devices are able to send, receive, and interpret data." The PHY layer(s) 116A and 116B in Lu carry channel bonding and shortened guard interval indicators, which are software parameters enabling devices 110A, 110b to send, receive, and interpret data according to the second wireless protocol. A POSITA would recognize that Lu discloses "means for" and "instructions to combine" adjacent channels "using channel bonding with orthogonal frequency division multiplexing (OFDM)" according to the second wireless protocol.

379. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

e. Claims [1.4], [16.4], [18.4]: transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel

Claim	Limitations
[1.4]	transmitting data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel to a receiver

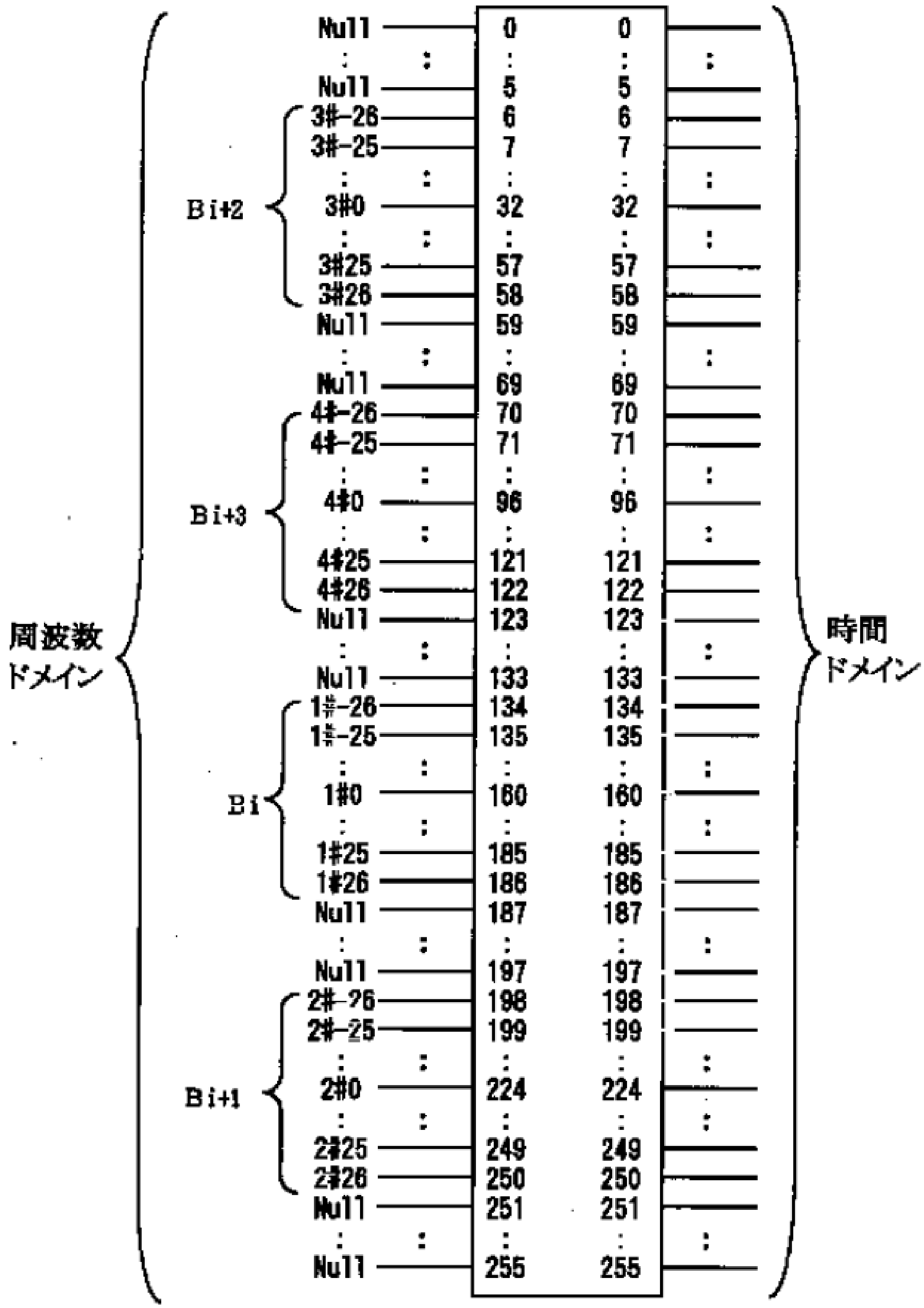
[16.4]	means for transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel to a receiver
[18.4]	instructions to transmit data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel to a receiver

380. As discussed above, a POSITA would understand "in parallel" to be satisfied by either (a) channel subcarriers that are parallel (non-overlapping) in frequency, or (b) use of spatial diversity (MIMO). The '326 Patent describes "two parallel channels" employed for "concatenation of two (or more) channels using parallel transceivers at the transmit and/or receive end" as involving "parallelizing the signals in frequency." Ex.1001, 4:6, 8:5, 11:29-30, 11:47-48. The '326 Patent also states that "a dual chain wideband radio receiver" employing "two channels in parallel" (e.g., "multiple, parallel receive chains designed to receive a single narrow signal") necessitates "a dual channel protocol", such as "instruct[ing] all legacy radios to go to channel 2 and stay off of channel 3 to prevent collision." Ex.1001, 12:65-66, 13:9-13, 14:20-21. A POSITA would therefore understand "data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel" to be satisfied by sets of subcarriers that are parallel in frequency occupying the channels and the frequency gap. However, the '326 Patent also describes a result of "using multiple input multiple output (MIMO)" (that is, "spatial

multiplexing … using MIMO technique") is that "the bandwidth is doubled with two signals in parallel." Ex.1001, 5:53-54, 12:54, 12:59-60. A POSITA would therefore understand "transmitting … in parallel to a receiver" to be satisfied by use of MIMO.

381. Mori discloses that a "practical wireless access system uses a bandwidth of 100 MHz in the 5 GHz band, with four channels spaced 20 MHz apart, and communication is conducted through each channel." Mori, Ex.1008, [0003]. As discussed above, Mori describes transmitting data for user C on adjacent channels B1 and B2 with the guard band therebetween filled with data subcarriers. Mori discloses that the "multi-carrier signal generation device 10" used to transmit data for user C on adjacent channels B1 and B2 (and on data subcarriers in the intervening guard band) includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor includes outputs 0 to 255 for outputting the results of the four 64-point IFFTs in parallel, as shown in Fig. 3 reproduced below.

【図3】


周波数
ドメイン
時間
ドメイン
Bi+2
Bi+3
Bi
Bi+1
Null
3#-26
3#-25
3#0
3#25
3#26
4#-26
4#-25
4#0
4#25
4#26
1#-26
1#-25
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Ex.1007, Fig. 3. Mori therefore discloses signal outputs from the 256-point IFFT processor suitable for coupling with one or more antennas.

382. Mori explicitly discloses a 256-point IFFT processor generating OFDM symbols for the two adjacent channels B1 and B2 using all 64 subcarriers for each channel, including the terminals for channel edge subcarriers that would receive a "Null" signal if a guard band is employed but receive data subcarriers. A POSITA would recognize that Lu and Williams, when combined with Mori as described above, disclose a "means for transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

383. In the context of maintaining compatibility between "a first wireless protocol (e.g., 802.11a, 802.11g)" and "a second wireless protocol (e.g., 802.11n)," Lu describes "a MIMO (Multiple Input Multiple Output) indication bit, wherein a '0' value indicates STTD (Space-Time Transmit Diversity) and a '1' value indicates VLST (Vertical Layered Space Time) diversity," "a channel bonding indicator bit, wherein a '1' value indicates that a channel bonding mechanism is used" with "one such channel bonding mechanism … simultaneously transmit[ting] data frames over two adjacent channels as if it were a single channel with twice the bandwidth," and "a shortened guard interval indicator bit, wherein a '1' value [that] indicates a shortened guard interval has been used (e.g., the interval guard may be shortened from 800 ns to 400 ns when a data rate of 140 Mbps is used)." Ex.1010, [0026]. A

POSITA would understand the "shortened guard interval" combined with "when a data rate of 140 Mbps" to indicate that guard band subcarriers are used for data. A POSITA would also understand MIMO, channel bonding, and a shortened guard interval to all be distinct but compatible, suitable for use either separately or together in any permutation of combinations (e.g., MIMO and channel bonding, MIMO and a shortened guard interval, channel bonding and a shortened guard interval, or all three of MIMO and channel bonding and a shortened guard interval).

384. The MIMO indication bit in Lu defines an "antenna configuration." Ex.1010, [0025] (including Table 3), [0026]-[0028], [0038], [004] (including Table 4).

385. A POSITA would be motivated to employ MIMO, channel bonding, and a shortened guard interval, each disclosed by Lu, together in order to obtain the known benefits of those distinct techniques. In implementing both channel bonding and a shortened guard interval as described by Lu, a POSITA would recognize the channel bonded and gap-filled adjacent bands B1 and B2 of Mori as an example of the two techniques in combination, and would use that approach so that "the area of the guard band may be effectively utilized" as taught by Mori. Ex.1008, [0131]. For the combination of both channel bonding and a shortened guard interval with MIMO, a POSITA would be motivated to select the "adjacent bands B1 and B2" as taught by Mori, for one spatial transmission path from antenna 19 to antenna 21 in Mori,

among multiple spatial transmission paths resulting from use of MIMO. This would be a combination of known elements with predictable results.

386. When adjacent channels B1 and B2 with data subcarriers inserted into the guard band(s) therebetween, as disclosed in Mori, are combined with MIMO based on Lu, the two OFDM symbols for channels B1 and B2 (and associated guard band region data subcarriers) will be transmitted according to the antenna configuration corresponding to the MIMO indicator, using the spatial transmission paths for that antenna configuration.

387. Mori discloses a "multi-carrier signal generation device 10" that includes "a carrier mapping circuit 13, an IFFT circuit 14, an orthogonal modulation circuit 15, a BPF (band pass filter) 16, and an upconverter (U/C) 17." Ex.1008, [0045]. The device 10 operates on adjacent channels B1 and B2, and the 256-point IFFT processor of Fig. 3 simultaneously performs 64-point IFFT operations on multiple channels. Mori therefore discloses a "means for transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

388. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. The 256-point IFFT processor is necessarily programmable, with some input terminals for each 64-point IFFT selectively

receiving either a "Null" signal or data, depending on whether a guard band is being included between adjacent channels. The 256-point IFFT has parallel outputs for the four 64-point IFFTs performed simultaneously therein. A POSITA would recognize that Mori discloses "instructions to transmit the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

389. Lu discloses device 102 that includes a transceiver 104 and "implement[s] a first wireless protocol (e.g., 802.11a, 802.11g)" and devices 110A, 110B that each include a respective a transceiver 112A, 112B and that "implement a second wireless protocol (e.g., 802.11n)." Ex.1010, [0015]. The "devices that use the first protocol … communicate with devices that use the second protocol and vice versa." Ex.1010, [0014]. The PHY layer(s) 116A and 116B in Lu carry channel bonding and shortened guard interval indicators, which are software parameters enabling devices 110A, 110b to send, receive, and interpret data according to the second wireless protocol. A POSITA would recognize that Lu discloses "means for transmitting the first plurality of subcarriers, the second plurality of subcarriers, and the at least one additional subcarrier in parallel."

390. Lu relates to "devices [that] communicate [using] a wireless protocol (i.e., standard) … defin[ing] hardware and software parameters such that the devices are able to send, receive, and interpret data." A POSITA would recognize that Lu discloses "instructions to transmit the first plurality of subcarriers, the second

plurality of subcarriers, and the at least one additional subcarrier in parallel" within devices using the combination of MIMO, channel bonding, and a shortened guard interval according to the second wireless protocol.

391. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

f. Claim [2.0] interleaving legacy and wide signals

Claim	Limitations
[2.0]	The method of claim 1, wherein combining the first channel and the second channel further comprises: interleaving one of a legacy signal and a wide signal during packet transmission

392. As discussed above, a POSITA would note that, in the '326 Patent, "legacy signals" simply means one channel and "wide signals" simply means multiple (channel bonded) channels. Ex.1001, 14:7-8. Therefore, interleaving a legacy (one-channel) signal with a wide (multi-channel) signal would be well understood to a POSITA. The '326 Patent states that "[l]egacy signals (e.g., one-channel) and wide signals (e.g., multiple-channels) may be arbitrarily interleaved in time (dynamic bandwidth switching) during packet transmission." Ex.1001, 14:710. A POSITA would understand "interleaving" as satisfied by sending the "legacy signals" and the "wide signals" at different times or in different data packets.

393. Mori describes "a multi-carrier signal is generated using the bandwidths B1, B2, and B4 for user C to communicate using the multi-carrier signal." Ex.1008, [0077], see also [0090]. In the example, channel bonding and gap filling are used for channels B1 and B2 while channel B4 is used alone. Ex.1007, Fig. 9(c), Ex.1008, [0121]. A POSITA would understand the data packet(s) for channel bonded and gap filled channels B1 and B2 could be interleaved with data packets for channel B4.

394. Lu discloses that the MIMO indicator, the channel bonding indicator bit, and the shortened guard indicator bit each have two states, one state respectively indicating use of MIMO and/or channel bonding and/or a shortened guard interval, and another state respectively indicating non-use of MIMO and/or channel bonding and/or a shortened guard interval. Ex.1010, [0026]. A POSITA would understand that use of channel bonding and/or a shortened guard interval under the second wireless protocol would produce "wide" signals, while non-use of both channel bonding and a shortened guard interval under the first wireless protocol would produce "legacy" signals. A POSITA would expect either of devices 110A, 110B to interleave "wide" and "legacy" signals among data packets transmitted, depending on the respective device was communicating with the other of devices 110A, 110B or with device 102. In addition, a POSITA would understand that use of MIMO with channel bonding and/or a shortened guard interval under the second wireless protocol would understand devices 110A, 110B to interleave "wide" and "legacy"

signals among data packets transmitted, depending on the respective device was communicating with the other of devices 110A, 110B or with device 102.

395. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

g. Claim [3.0] interleaving legacy and wide signals

Claim	Limitations
[3.0]	3. The method of claim 2, wherein the legacy signal comprises one channel and the wide signal comprises multiple channels

396. As discussed above, Mori describes "a multi-carrier signal is generated using the bandwidths B1, B2, and B4 for user C to communicate using the multi-carrier signal." Ex.1008, [0077], see also [0090]. In the example, channel bonding and gap filling are used for channels B1 and B2 while channel B4 is used alone. Ex.1007, Fig. 9(c), Ex.1008, [0121].

397. As also discussed above, the first wireless protocol in Lu necessarily uses one channel "legacy" signals, while the second wireless protocol in Lu may use channel bonded, multiple channel "wide" signals.

398. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

h. Claim [4.0] transmitting to multiple radios

Claim	Limitations
[4.0]	The method of claim 1, wherein transmitting the first channel and the second channel comprises transmitting to multiple radios

399. As discussed above, a POSITA would understand that a wireless signal is inherently transmitted to the number of radios that are in range of the transmitter. If multiple radios are in range, the signal is transmitted to multiple radios.

400. To the extent that an intent is read into the claim language (i.e., that "the first channel and the second channel" are intended for "multiple radios"), a POSITA would understand "transmitting to multiple radios" to be satisfied by "using two existing legacy circuits or radios in parallel" using MIMO. Ex.1001, 11:24. The '326 Patent teaches that "the high data rate multi-channel arrangement of the invention may be achieved, for example, by 1) using two existing legacy circuits or radios in parallel" with "one physical implementation of a dual-chain wideband radio" using "a 'multiple radios in a box' implementation" in which "multi-chain radios each with a single bandwidth … are used." Ex.1001, 11:24-26, 12:9-15.

401. Mori describes three users (user A, user B, and user C) sharing eight channels B1 through B8. "[A]mong bandwidths B1 to B8, B3 indicated as a) is already used by user A, and B6 and B7 are already used by user B, while user C is in a situation

where communication is performed by setting three of the remaining B1, B2, B4, B5, and B8 bandwidths." EX.1008, ¶[0074]. In one example, Mori describes "signals using three bands B1, B2, and B4, where consecutive multi-carrier signals are arranged between the adjacent bands B1 and B2," for a user C. Ex. 1008, [0077], [0120]-[0122], see Fig. 8(c). The "multi-carrier signal is generated using the bandwidths B1, B2, and B4 for user C to communicate using the multi-carrier signal generation device," and used for "communicating using multiple unit communication [channels], even when they are not consecutive, thus improving channel utilization efficiency." EX.1008, ¶¶[0075], [0077], [0148]. POSITAs would understand that the multi-carrier signal for channels B1, B2, and B4 transmitted via antenna 19 in Mori would be transmitted to radios for user A and user B, which share the same channels.

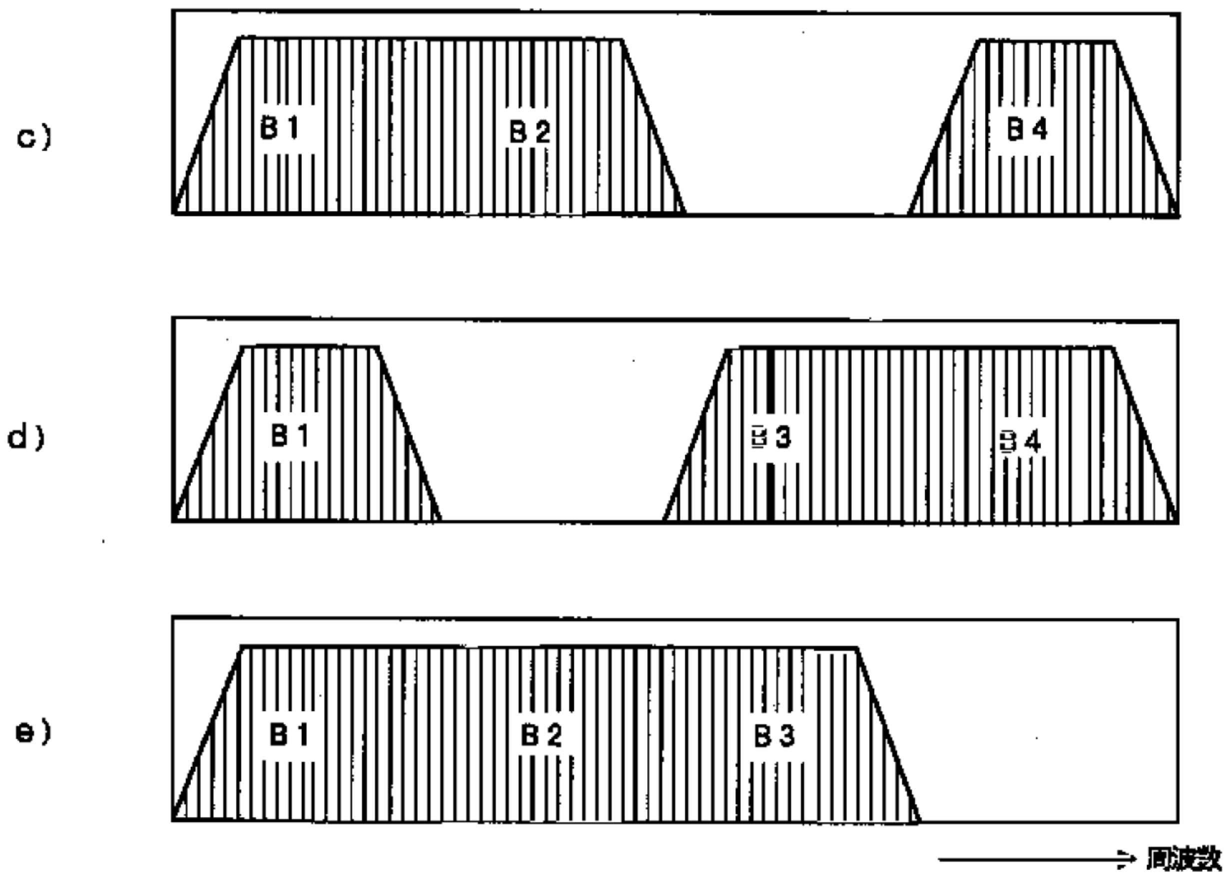
402. Lu describes the second wireless protocol as supporting MIMO. Ex.1010, [0026]. As discussed above, a POSITA would be motivated to employ MIMO, channel bonding, and a shortened guard interval, all disclosed by Lu, together in order to obtain the known benefits of those distinct techniques. Lu also discloses devices 102, 110A, and 110B each having transceivers. EX.1010, Fig. 1. Lu also describes a case in which "devices (e.g., 110A, 110B)…implement the second [wireless] protocol." EX.1010, ¶[0050]. A POSITA would therefore understand that when either of devices 110A or 110B transmits OFDM symbols using the second

wireless protocol with channel bonding, the resulting signal is transmitted to a radio for device 102 and a radio for the other one of devices 110A or 110B, which are in wireless communication.

403. A POSITA would recognize that Mori, when combined with Lu as described above and employing MIMO, channel bonding, and a shortened guard interval together, suggests transmitting channel bonded and gap filled channels B1 and B2 and single channel B4, alone, to multiple radios via separate MIMO transmission paths.

404. Alternatively, as discussed above, Mori depicts and describes channel bonding and gap filling of three channels B1, B2, and B3, "since bands B1 to B3 are used consecutively, consecutive multi-carrier signals are arranged in bands B1 to B3." Ex.1008, [0122]. The use of channel bonding and gap filling with three consecutive channels B1, B2 and B3 is depicted in Fig. 8(e) of Mori, which is reproduced below.

【図8】



Ex.1007, Figs. 8(c)-(e). Mori states that "data may be allocated to 10 subcarriers each between B1 and B2 and between B2 and B3, totaling 20 subcarriers, resulting in an increase in transmission rate." Ex.1008, [0126]. Mori further states that, "when communication is conducted using four consecutive bands, data allocation may be made to a total of 30 subcarriers, resulting in an increase in transmission rate." Mori, Ex.1008, [0127]. A POSITA would understand Mori to describe using all four channels B1, B2, B3 and B4 with channel bonding and gap filling.

405. Lu describes a single bit channel bonding indicator and a single bit shortened guard interval indicator. A POSITA would understand that multiple channel bonding indicator bits and multiple shortened guard interval indicator bits (e.g., two bits each) would allow the indication of channel bonding and gap filling to be extended to more than two consecutive channels, as suggested by Mori.

406. A POSITA would recognize that, with two bit indicators as suggested by Mori and channel bonding and gap filling in four consecutive channels B1 through B4 as described by Mori, MIMO transmission as taught by Lu could use a first spatial transmission path for channel bonded and gap filled adjacent channel pair B1 and B2 and a second spatial transmission path for channel bonded and gap filled adjacent channel pair B3 and B4.

407. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

i. Claim [5.0] transmitting to a single radio

Claim	Limitations
[5.0]	The method of claim 1, wherein transmitting the first channel and the second channel comprises transmitting to a single radio

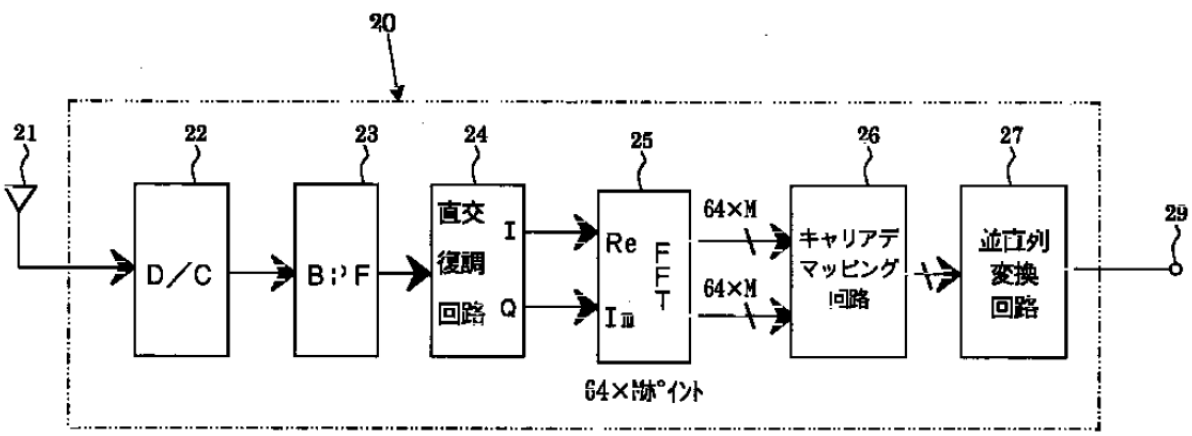
408. As discussed above, a POSITA would understand that a wireless signal is inherently transmitted to the number of radios that are in range of the transmitter. If only a single radio is in range, the signal is transmitted to that single radio.

409. To the extent that an intent is read into the claim language (i.e., that "the first channel and the second channel" are intended for "a single radio"), Mori explicitly discloses receiving channel bonded and gap-filled adjacent channels B1 and B2 by a single radio. "Thus, the OFDM signal radiated from the OFDM signal generation device 10a into the spatial transmission path is received and decoded by the OFDM signal decoding device 20a, and the operation for decoding is performed based on the demodulated output of the FFT 25a that operates in synchronization with the IFFT 14a." Ex.1008, [0021]. A POSITA would understand this as describing receiving the first and second channels B1 and B2 by a single decoding device 20a.

410. Mori also states that "user C is in a situation where communication is performed by setting three of the remaining B1, B2, B4" among channels B1 through B8, and describes "multi-carrier signals for communication using B1, B2." Ex.1008, [0074]-[0075]. A POSITA would understand the wireless signal for channel bonded and gap-filled adjacent channels B1 and B2 to be transmitted to a single radio for user C. Mori describes the "transmission signal from this generation device [10 of Fig. 1] is supplied to an antenna 19 and radiated into the spatial transmission path from that antenna." Ex.1008, [0045].

411. At the receiver, Mori describes the "transmission signal supplied to the spatial transmission path is received by an antenna 21 and supplied to … the multi-carrier signal decoding device 20 … composed of a downconverter (D/C) 22, a BPF 23, an orthogonal demodulation circuit 24, an FFT (Fast Fourier Transform; fast Fourier transform) 25, a carrier demapping circuit 26, a parallel-serial conversion circuit 27, and an information signal output terminal 29." Ex.1008, [0046]. The receiver is illustrated as a single chain radio in Fig. 3, which is reproduced below.

【図２】



Ex.1007, Fig. 2.

412. Lu discloses device 102, 110A, and 110B each having transceivers. EX.1010, Fig. 1. Lu also describes that "device 102 may implement a first wireless protocol (e.g., 802.11a, 802.11g)" and "devices (e.g., 110A, 110B)…implement the second [wireless] protocol" where "the devices that use the first protocol may communicate

with each other using a different (e.g., lower) data transfer rate than the devices that communicate using the second protocol." Ex.1010, [0014]-[0015]. A POSITA would therefore understand that when either of devices 110A or 110B transmits OFDM symbols using the second wireless protocol with channel bonding, the resulting signal is "received by" the other one of devices 110A or 110B and not by device 102.

413. A POSITA would recognize that Mori, when combined with Lu as described above and even when employing MIMO, channel bonding, and a shortened guard interval together, discloses transmitting channel bonded and gap filled channels B1 and B2 via a single spatial transmission path to the radio for user C.

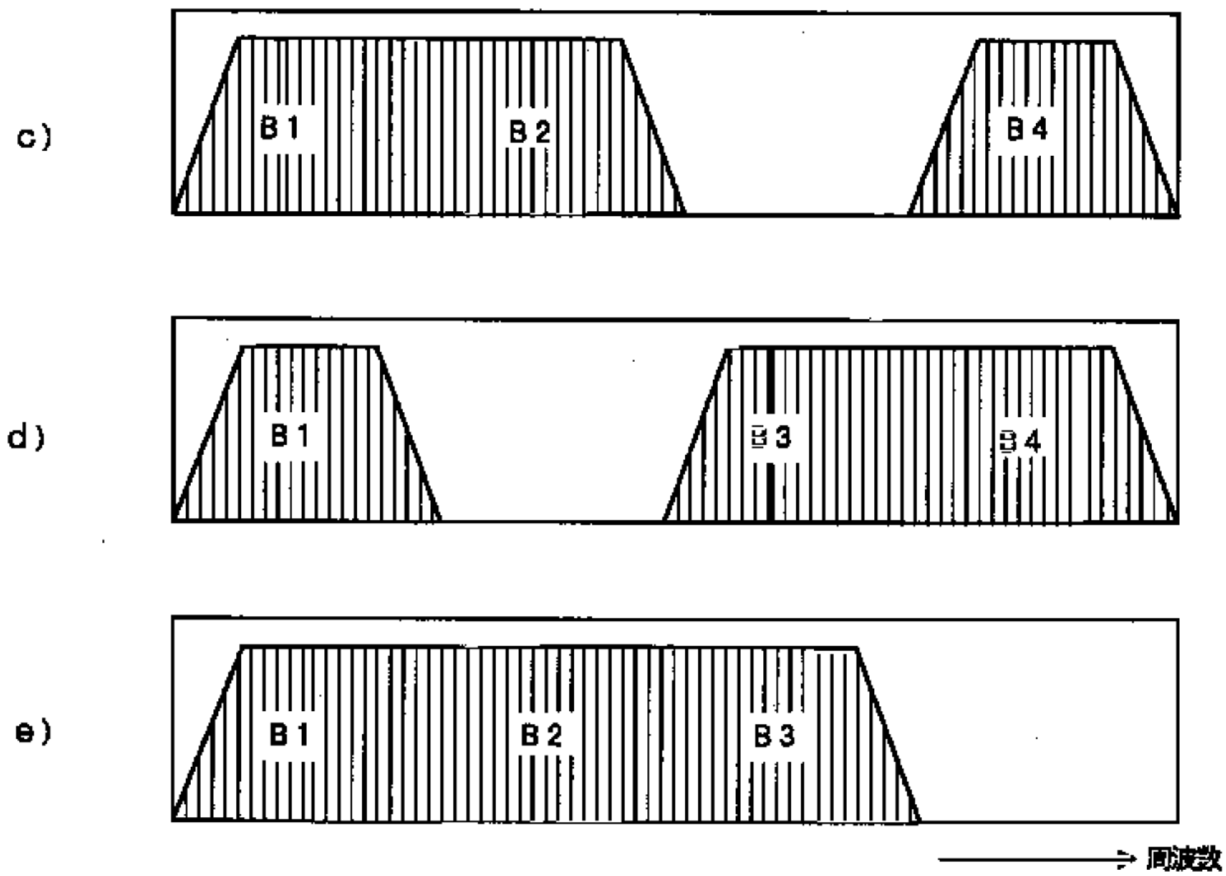
414. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

j. Claim [6.0] extensible to additional channels

Claim	Limitations
[6.0]	The method of claim 1, wherein the method is extensible to additional channels

415. As discussed above, Mori depicts and describes channel bonding and gap filling of three channels B1, B2, and B3, "since bands B1 to B3 are used consecutively, consecutive multi-carrier signals are arranged in bands B1 to B3." Ex.1008, [0122]. The use of channel bonding and gap filling with three consecutive channels B1, B2 and B3 is depicted in Fig. 8(e) of Mori, which is reproduced below.

【図8】



Ex.1007, Figs. 8(c)-(e). Mori states that "data may be allocated to 10 subcarriers each between B1 and B2 and between B2 and B3, totaling 20 subcarriers, resulting in an increase in transmission rate." Ex.1008, [0126]. Mori further states that, "when communication is conducted using four consecutive bands, data allocation may be made to a total of 30 subcarriers, resulting in an increase in transmission rate."Ex.1008, [0127].

416. Lu describes a single bit channel bonding indicator and a single bit shortened guard interval indicator. A POSITA would understand that multiple channel bonding indicator bits and multiple shortened guard interval indicator bits (e.g., two bits each) would allow the indication of channel bonding and gap filling to be extended to more than two consecutive channels, as suggested by Mori.

417. A POSITA would recognize that modifying Lu to use two bit channel bonding and shortened guard interval indicators as suggested by Mori would support channel bonding and gap filling in four consecutive channels B1 through B4 as described by Mori.

418. A POSITA would recognize that Mori, when combined with Lu as described above, discloses extension of channel bonding and gap filling to more than two adjacent channels.

419. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

k. Claim [7.0] eliminating synthesizer frequency popping

Claim	Limitations
[7.0]	7. The method of claim 1, further comprising eliminating synthesizer frequency popping during bandwidth switching between packets

420. As discussed above, the ‘326 Patent describes “using a full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)” with dual chain “‘multiple radios in a box’” design in which “multi-chain radios, each with a single bandwidth and multiple FFTs” “use common synthesizer” frequencies without bandwidth switching by “stay[ing] tuned to legacy channel centers.” Ex.1001, 4:50-54, 10:48-53, 12:9-17.

421. Mori describes “simultaneously generating the subcarrier signals provided to the two or more unit communication bands,” using a 256-point IFFT “performing 64-point IFFT operations simultaneously” on four channels, and that “modulation signals for the four bands … are generated simultaneously by the aforementioned IFFT.” Ex.1008, [0066], [0071].

422. A POSITA would recognize that Mori, when combined with Lu as described above, discloses four parallel 64-point IFFTs that each remain tuned to legacy channel centers even when generating signals for channel bonded and gap-filled adjacent channels B1 and B2.

423. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

l. Claim [8.0] tuning a first synthesizer to the first channel

Claim	Limitations
[8.0]	8. The method of claim 1 further comprising: tuning a first synthesizer to the first channel, wherein the first synthesizer remains tuned to the first channel during mode switching; and

424. As discussed above, the ‘326 Patent describes “using a full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)” with dual chain “‘multiple radios in a box’” design in which “multi-chain radios, each with a single bandwidth and multiple FFTs” “use common synthesizer” frequencies without bandwidth switching by “stay[ing] tuned to legacy channel centers.” Ex.1001, 4:50-54, 10:48-53, 12:9-17.

425. A POSITA would recognize that Mori, when combined with Lu as described above, discloses four parallel 64-point IFFTs that each remain tuned to legacy channel centers even when generating signals for channel bonded and gap-filled adjacent channels B1 and B2, with a first of the 64-point IFFTs remaining tuned to channel B1 regardless of whether channel bonding and gap-filling with adjacent channel B2 is being performed.

426. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

m. Claim [8.1] tuning a second synthesizer to the second channel

Claim	Limitations
[8.1]	tuning a second synthesizer to the second channel, wherein the second synthesizer remains tuned to the second channel during mode switching

427. See the preceding discussion regarding claim [8.0].

428. A POSITA would recognize that Mori, when combined with Lu as described above, discloses four parallel 64-point IFFTs that each remain tuned to legacy channel centers even when generating signals for channel bonded and gap-filled adjacent channels B1 and B2, with a second of the 64-point IFFTs remaining tuned to channel B2 regardless of whether channel bonding and gap-filling with adjacent channel B1 (or adjacent channel B3) is being performed.

429. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

n. Claim [9.0] use of common synthesizers

Claim	Limitations
[9.0]	9. The method of claim 1, wherein channel bonding comprises use of common synthesizers

430. A POSITA would understand that use of the "full spectral synthesis capability of the Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT/FFT)" with dual chain "'multiple radios in a box'" design including "multi-chain radios, each with a single bandwidth and multiple FFTs" results in "use [of] common synthesizer" frequencies without bandwidth switching by "stay[ing] tuned to legacy channel centers." Ex.1001, 4:50-54, 10:48-53, 12:9-17. That is, the IFFT frequency synthesis is "common" to both using adjacent channels individually and using the same adjacent channels with channel bonding and gap filling, without switching center frequencies.

431. Mori describes "simultaneously generating the subcarrier signals provided to the two or more unit communication bands," using a 256-point IFFT "performing 64-point IFFT operations simultaneously" on four channels, and that "modulation signals for the four bands … are generated simultaneously by the aforementioned IFFT." Ex.1008, [0066], [0071].

432. A POSITA would recognize that Mori, when combined with Lu as described above, discloses four parallel 64-point IFFTs that are "common synthesizers" each remaining tuned to legacy channel centers regardless of whether when generating signals for adjacent channels B1 and B2 individually or for channel bonded and gap-filled adjacent channels B1 and B2.

433. For at least these reasons, Mori as combined with Lu and Williams renders these elements obvious.

o. Claim [10.0] OFDM subcarriers

Claim	Limitations
[10.0]	10. The method of claim 1, wherein the plurality of data subcarriers are OFDM subcarriers

434. Mori likewise discloses "an OFDM signal with a subcarrier frequency interval of 312.5 kHz." Ex.1008, [0012], see also [0002], [0011], [0020], [0021].

435. Lu utilizes OFDM. Ex.1010, Fig. 3, [0024], [0025] (including Table 3), [0029], [0034], [0037].

436. A POSITA would recognize that Mori, when combined with Lu as described above, uses data subcarriers that are OFDM subcarriers.

437. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

p. Claim [11.0] additional points

Claim	Limitations
[11.1]	11. The method of claim 10, further comprising: identifying additional points in a Fast Fourier Transform (FFT) across the first and second channels; and

438. See the discussions in in §III.G.9 and III.H.2.p regarding "additional points." A POSITA would recognize that, whether used for data or null signals for the guard

band, subcarriers (or IFFT points) intrinsically exist on the edges of an IEEE 802.11 64 subcarriers channel.

439. Mori discloses that the IFFT circuit 14 may be implemented by "a 256-point IFFT processor performing 64-point IFFT operations simultaneously on four systems." Ex.1008, [0066]. Whether used for a guard band or to carry data, the edge subcarriers ("additional points") are present in the 64-point IFFTs of Mori.

440. Williams states that "guard bands [may] contain repeated data [or] unused data" under the IEEE 802.11a standard. Ex. 1011, [0007], see also [0008]. A POSITA would understand "unused data" to refer to null signals, and would also understand that the IEEE 802.11a standard does not add additional subcarriers ("additional points") to the underlying channel structure when repeated data is used instead of null signals.

441. A POSITA would recognize that Mori, when combined with Lu as described above and in light of Williams, discloses that "additional points" in the 64-point IFFTs correspond to guard band subcarriers for channels B1 and B2.

442. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

q. Claim [11.1] adding subcarriers to the additional points

Claim	Limitations
[11.1]	adding subcarriers to the additional points

443. As discussed above, a POSITA would recognize that the channel structure in IEEE 802.11 systems comprises, for each 20MHz channel, 64 subcarriers equally spaced (in the frequency domain), separated by 312.5KHz.

444. To the extent that adding ***data*** subcarriers to an IEEE 802.11 channel is considered, Mori states that "data allocation may be made for 10 subcarriers at 10 input terminals" to produce an "increase in transmission rate due to the increase in subcarriers" by "the addition of 10 subcarriers in the guard band area." Ex.1008, [0124]-[0125]. Mori also states that, "because subcarrier signals [to be] inserted between bands B1 and B2 are generated, data allocation may be made for 10 subcarriers at 10 input terminals … among input terminals 187 to 197" of the 256-point IFFT processor. Ex.1008, [0124]. A POSITA would recognize that input terminals 187 to 197, labeled "Null" in Fig. 3, correspond to "subcarriers #−32 to #−27" for one channel and "subcarriers … #+27 to #+31" for an adjacent channel, corresponding to a guard band between the two channels. See Ex.1008, [0113]-[0115].

445. Lu describes "a shortened guard interval indicator bit, wherein a '1' value [that] indicates a shortened guard interval has been used (e.g., the interval guard may be shortened from 800 ns to 400 ns when a data rate of 140 Mbps is used)." Ex.1010, [0026]. A POSITA would understand the "shortened guard interval" combined with "when a data rate of 140 Mbps" to indicate that guard band subcarriers are used for data.

446. A POSITA would recognize that Mori, when combined with Lu as described above, discloses adding data subcarriers to the "additional points" in the 64-point IFFTs that correspond to guard band subcarriers for channels B1 and B2.

447. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

r. Claim [12.0] additional points on an outer edge

Claim	Limitations
[12.0]	12. The method of claim 11, wherein the additional points exist on an outer edge of the first channel or the second channel

448. See the discussion of "additional points" in connection with claim [11.0] within §III.H.2.p.

449. As discussed above, POSITA would note that the guard band subcarriers between adjacent first and second channels correspond to "additional points" on an outer edge of the first channel and on an outer edge of the second channel. Mori

states that “data allocation may be made for 10 subcarriers at 10 input terminals” to produce an “increase in transmission rate due to the increase in subcarriers” by “the addition of 10 subcarriers in the guard band area” between adjacent channels B1 and B2. Ex.1008, [0124]-[0125]. A POSITA would recognize a first portion of those “10 subcarriers in the guard band area” between adjacent channels B1 and B2 correspond “additional points … on an outer edge of the first channel” while a second portion of the “10 subcarriers in the guard band area” between adjacent channels B1 and B2 correspond “additional points exist on an outer edge of … the second channel.”

450. Alternatively, to the extent that outer edges of the combined first and second channels is considered, Williams describes “generation of the guard bands that contain repeated data” by “replicat[ing] a percentage of the data at one end of the [data stream] and places that percentage at the other end,” within the guard band. Ex.1011, [0008]. Williams teaches that this is permitted by the IEEE 802.11a standard. Ex.1011, [0007].

451. A POSITA would recognize that Mori, when combined with Lu and Williams as described above, discloses filling the guard band on the edge of channel B1 with repeated data for channel B1—on an “outer” edge of the combined channels B1 and B2 (that is, the edge of channel B1 furthest to channel B2). This would have been a combination of known elements with predictable results.

452. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

s. Claims [13.0] guard band on each edge is filled

Claim	Limitations
[13.0]	The method of claim 12, wherein a guard band on each edge is filled with data

453. See the discussion of claim [12.0] within §III.J.2.r.

454. Mori teaches that "[e]ven when the OFDM signals that are orthogonal among multiple bands are generated using multiple IFFTs, when those IFFTs are, for example, synchronized to operate at the same symbol period, each subcarrier remains orthogonal, allowing for the omission of guard bands." Mori, Ex. 1008, [0118]. Mori discloses a 256-point IFFTs processor for simultaneously calculating four 64-point IFFTs.

455. Accordingly, a POSITA would be motivated to fill all guard bands with data, using the 256-point IFFTs processor of Mori to avoid errors.

456. Alternatively, Mori suggests "adding error correction codes" to guard band subcarriers. Ex.1008, [0129]. Williams describes "generation of the guard bands that contain repeated data" by "replicat[ing] a percentage of the data at one end of the [data stream] and places that percentage at the other end," within the guard band, to combat ISI. Ex.1011, [0008]. Williams teaches that this is permitted by the IEEE

802.11a standard. Ex.1011, [0007]. A POSITA would understand that the repeated data allows for error correction at the receiver.

457. A POSITA would recognize that Mori, when combined with Lu and Williams as described above, discloses filling the guard band on each edge of channel B1 with repeated data, using repeated for channel B1 on the edge of channel B1 furthest from channel B2 and repeated data for channel B2 on the edge of channel B1 closest to channel B2 (and repeated data for channel B3 on the edge of channel B2 closest to channel B3). This would have been a combination of known elements with predictable results.

458. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

t. Claims [14.0] anti-aliasing

Claim	Limitations
[14.0]	14. The method of claim 1, further comprising utilizing an anti-aliasing technique at a receiver

459. As discussed in §III.G.10, a POSITA would understand anti-aliasing to refer to use of low-pass filters to prevent aliasing artifacts when converting analog signals to digital format.

460. The '326 Patent describes "the undesired impact of analog-to-digital converter (ADC) sample-rate aliasing. ADC sample-rate aliasing may occur when a wide

signal is received by multiple, parallel receive chains designed to receive a single narrow signal." Ex.1001, 14:17-21. According to the '326 Patent, sample-rate aliasing results from "filter leakage associated with a radio processing one half of a signal while receiving both halves of the signal." Ex.1001, 14:26-28.

461. Mori teaches that "the generation device and decoding device can be configured with only one system of IFFT or FFT and filter corresponding to a number of points that is multiple times the unit communication bandwidth, enabling the transmission or reception of signals for multiple unit communication bands." Ex.1008, [0143]. The receiver (decoding device 20) in Mori includes a bandpass filter (BPF 23) in which "the signal components of the frequency bandwidth necessary for demodulation are frequency-selected." Ex.1008, [0088], see also [0016] ("the frequency band signal necessary for demodulation selected and extracted by a BPF 23"). A POSITA would recognize that a bandpass filter, which is more frequency-selective than a low pass filter, comprises utilizing an anti-aliasing technique at a receiver.

462. A POSITA would recognize that Mori, when combined with Lu and Williams as described above, discloses using a bandpass filter to "frequency-select[]" "the signal components of the frequency bandwidth necessary for demodulation," providing an anti-aliasing technique.

463. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

u. Claims [15.0] passing upper signals and lower signals through a first filter and a second filter

Claim	Limitations
[15.0]	15. The method of claim 14, wherein the anti-aliasing technique comprises passing upper signals and lower signals through a first filter and a second filter

464. Mori only discloses a single bandpass filter 23 within the receiver (decoding device 20. However, Mori teaches that the purpose of that bandpass filter 23 is to "select[] and extract[]" "the frequency band signal necessary for demodulation." Ex.1008, [0016].

465. The output of the bandpass filter 23 is passed to "orthogonal demodulation circuit 24," in which "the supplied signal is IQ demodulated to obtain the I and Q component signals, and the obtained signal is converted into a digital signal by an A/D converter that is not illustrated, and the converted I and Q signals are supplied to a 64-point FFT circuit 25a" "that operates in synchronization with the IFFT 14a." Ex.1008, [0017], [0021].

466. In decoding channel bonded and gap-filled adjacent channels B1 and B2, Mori teaches that FFT circuit 25a should "perform[] FFT operations on the supplied subcarrier signals with a degree of at least twice" "a predetermined number N (where

N is a natural number) of subcarriers." Ex.1008, [0041], see also [0043] ("performing FFT operations on the subcarrier signals supplied to the multiple unit communication bands with a degree of at least twice N to obtain calculation results").

467. In a specific embodiment, Mori states that the "FFT 25 in the multi-carrier signal decoding device 20 has an input terminal for 256 time-domains corresponding to the IFFT illustrated in FIG. 3, … and 256 point FFT operations are performed to generate output signals of the 256 frequency domains by performing FFT operations on the signals supplied to the terminal." Ex.1008, [0083]. A POSITA would understand these teachings to mean that the 256-point FFT simultaneously performs four 64-point FFTs, analogous to the 256-point IFFT processor of Fig. 3.

468. Since the purpose of that bandpass filter 23 is to "select[] and extract[]" "the frequency band signal necessary for demodulation" before time domain to frequency domain conversion, and since the 256-point FFT simultaneously performs four 64-point FFTs, a POSITA would be motivated to implement a separate bandpass filter for each channel on which the 256-point FFT operates, to "select[] and extract[]" "the frequency band signal" for the respective channel. That is, a POSITA would be motivated to use a first bandpass filter for channel B1, a second bandpass filter for channel B2, a third bandpass filter for channel B3, and a fourth bandpass filter for channel B4.

469. A POSITA would recognize that Mori, when combined with Lu and Williams as described above, suggests using a first bandpass filter to "frequency-select[]" "the signal components of the frequency bandwidth" for channel B1 of channel bonded and gap-filled adjacent channels B1 and B2, and using a second bandpass filter to "frequency-select[]" "the signal components of the frequency bandwidth" for channel B2 of channel bonded and gap-filled adjacent channels B1 and B2.

470. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

v. Claims [17.0] frequency gap is filled

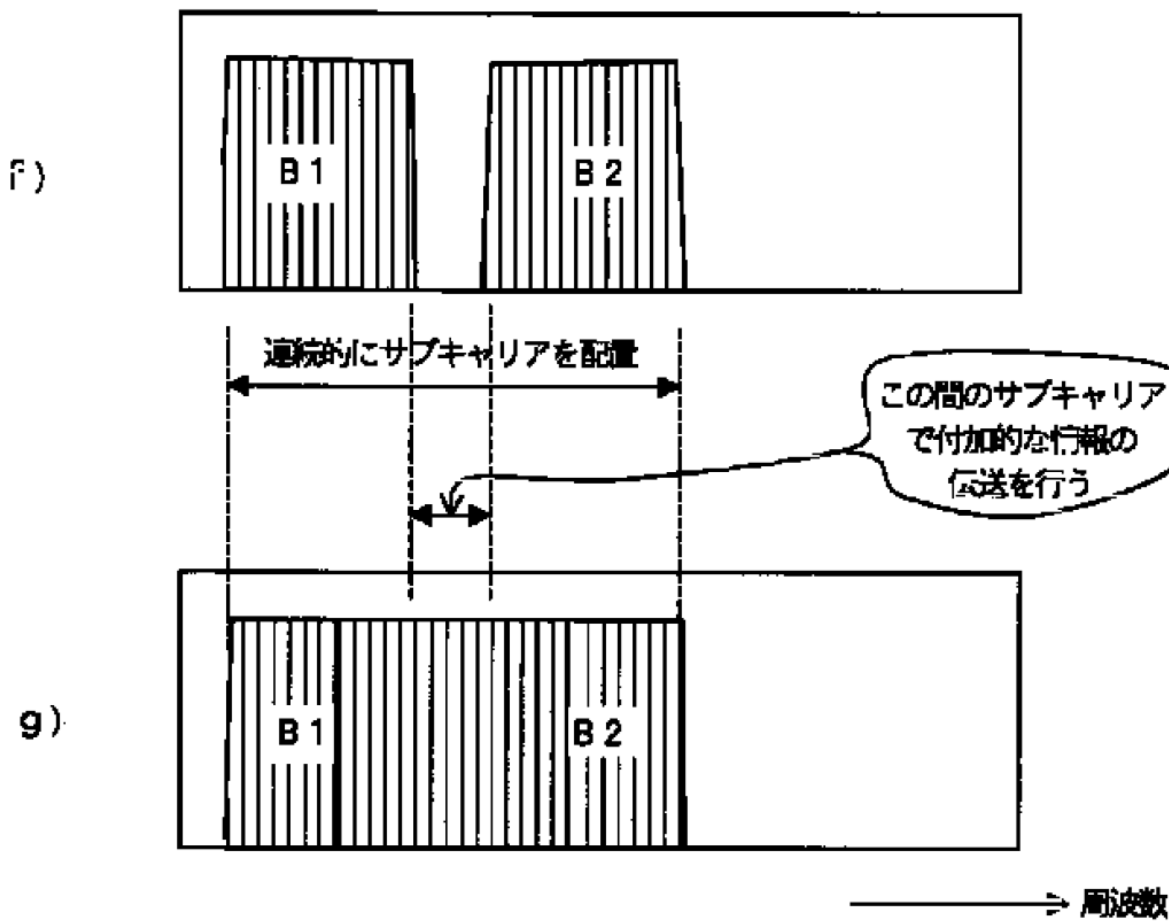
Claim	Limitations
[17.0]	17. The system of claim 16, wherein the frequency gap is filled with a portion of the first plurality of subcarriers and a portion of the second plurality of subcarriers

471. See the discussion of claim [16.2] in §III.J.2.c.

472. As discussed above, Mori discloses the "addition of 10 subcarriers in the guard band area" between adjacent channels B1 and B2 to "increase the number of data carriers by allocating subcarrier data to the guard band between the consecutive bands B1 and B2" and obtain an "increase the number of multi-carriers compared to when guard bands are provided, resulting in a larger transmission rate." Ex.1008, [0123], [0125]. Mori depicts the additional data subcarriers as filling the guard band

between channels B1 and B2 in Fig. 9(g), which is reproduced (together with Fig. 9(f)) below.

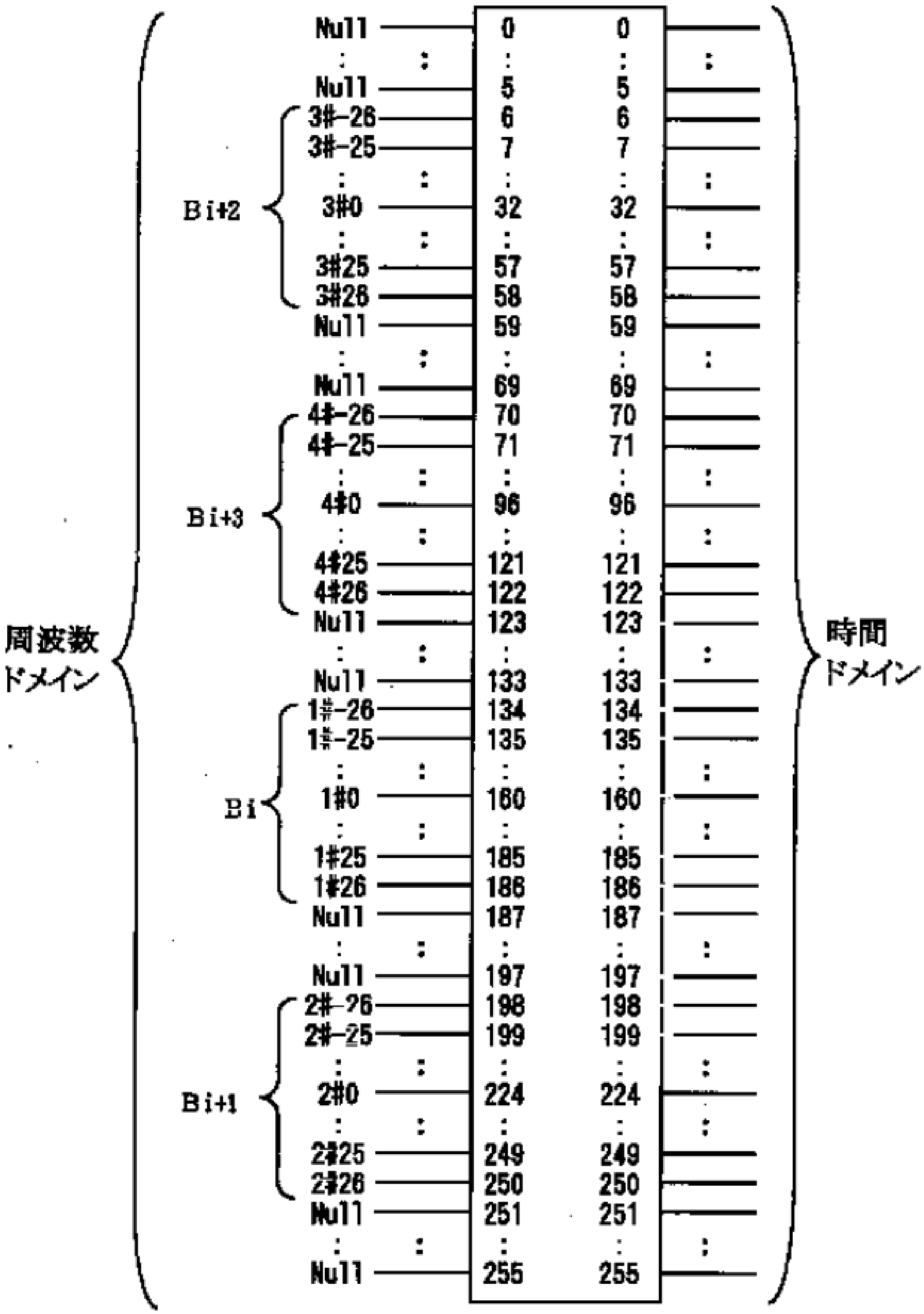
【図9】



Ex.1007, Figs. 9(f)-(g). “In this way, the area of the guard band may be effectively utilized.” Ex.1008, [0131].

473. Mori teaches that the additional 10 data subcarriers are input “at 10 input terminals … among input terminals 187 to 197.” Ex.1008, [0124]. Those input terminals are depicted in Fig. 3, which is reproduced below.

【図３】



周波数
ドメイン
時間
ドメイン
Bi+2
Bi+3
Bi
Bi+1
Null
3#-26
3#-25
3#0
3#25
3#26
4#-26
4#-25
4#0
4#25
4#26
1#-26
1#-25
1#0
1#25
1#26
2#-26
2#-25
2#0
2#25
2#26
0 5 6 7 32 57 58 59 69 70 71 96 121 122 123 133 134 135 160 185 186 187 197 198 199 224 249 250 251 255

Ex.1007, Fig. 3. A POSITA would recognize that a first portion of input terminals 187 to 197 correspond to subcarriers in a guard band region at an edge of channel Bi (B1), and a second portion of input terminals 187 to 197 correspond to subcarriers in a guard band region at an edge of channel Bi+1 (B2).

474. A POSITA would recognize that Mori, when combined with Lu and Williams as described above, discloses using a portion of subcarriers for channel B1 and a portion of subcarriers for channel B2 to fill the guard band between channels B1 and B2 with data subcarriers.

475. Alternatively, Williams describes "generation of the guard bands that contain repeated data" by "replicat[ing] a percentage of the data at one end of the [data stream] and places that percentage at the other end," within the guard band. Ex.1011, [0008]. Williams teaches that this is permitted by the IEEE 802.11a standard. Ex.1011, [0007].

476. A POSITA would recognize that Mori, when combined with Lu and Williams as described above, discloses filling the guard band between channel B1 and channel B2 with repeated data for channel B2. This would have been a combination of known elements with predictable results.

477. For at least these reasons, Mori as combined with Lu and Willaims renders these elements obvious.

IV. Secondary Considerations

478. I have seen no evidence in either the '326 patent's prosecution history or elsewhere supporting any secondary considerations arguments, or evidence of nexus of such alleged evidence to the challenged claims. To the extent patent owner or its expert asserts the existence of any secondary considerations in its responses, I reserve the right to address any such evidence.

V. Conclusion

479. The findings and opinions set forth in this declaration are based on my work and examinations to date.

480. I may continue my examinations. I may also receive additional documentation and other factual evidence over the course of this IPR that will allow me to supplement and/or refine my opinions. I reserve the right to add to, alter, or delete my opinions and my declaration upon discovery of any additional information. I reserve the right to make such changes as may be deemed necessary.

481. In signing this declaration, I recognize that the declaration will be filed as evidence in an IPR before the PTAB. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

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

Date: May 23, 2025

Chuck Easttom, Ph.D., D.Sc.