# United States Court of Appeals for the Federal Circuit

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**BRADIUM TECHNOLOGIES LLC,**
*Appellant*

**v.**

**ANDREI IANCU, UNDER SECRETARY OF COMMERCE FOR INTELLECTUAL PROPERTY AND DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE,**
*Intervenor*

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2017-2579, 2017-2580

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Appeals from the United States Patent and Trademark Office, Patent Trial and Appeal Board in Nos. IPR2016-00448, IPR2016-00449.

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Decided: May 13, 2019

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MICHAEL SHANAHAN, Bradium Technologies, LLC, Suffern, NY, argued for appellant.

MICHAEL S. FORMAN, Office of the Solicitor, United States Patent and Trademark Office, Alexandria, VA, argued for intervenor. Also represented by THOMAS W. KRAUSE, JOSEPH MATAL, BRIAN RACILLA, FARHEENA YASMEEN RASHEED.

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Before MOORE, REYNA, and CHEN, *Circuit Judges*.

REYNA, *Circuit Judge*.

In this consolidated appeal, Bradium Technologies LLC appeals final written decisions of the Patent Trial and Appeal Board finding the claims of U.S. Patent Nos. 7,908,343 and 8,924,506 unpatentable as obvious in two *inter partes* review proceedings. Because the Board did not err in construing the relevant claim terms and because substantial evidence supports the Board's decision, we affirm.

## BACKGROUND

### I. The Patents at Issue

Bradium Technologies LLC ("Bradium") is the assignee of U.S. Patent Nos. 7,908,343 ("the '343 patent") and 8,924,506 ("the '506 patent"), both entitled "Optimized Image Delivery over Limited Bandwidth Communication Channels." The '506 patent is a continuation-in-part of the '343 patent. Both patents have similar written descriptions.[1]

The patents are broadly directed to retrieving large-scale images over network communication channels in low-bandwidth conditions and to displaying such images on client devices with limited processing power. The preferred embodiment of the invention includes an image server and a client device connected to each other over a network. The image server stores high-resolution and often three-dimensional ("3D") map or satellite imagery of geographic

[1] This opinion refers to the written description portions shared by both patents as the "shared written description." Where the written description language is the same, this opinion cites to the written description of the '343 patent.

regions. This high-resolution source image data is pre-processed by the image server to create a series of derivative copies of the image of progressively lower resolution. Each of the derivative images is subdivided into an array of fixed-size, discrete sections, which the shared written description calls "image parcels." The image parcels are stored on the image server in a file of predefined configuration, such that any image parcel can be located within a series of $K_{1\text{-}N}$ derivative images by specifying an address $K_D$, X, Y, where subscript D is the image resolution index, and X and Y are the corresponding image array coordinates. Figure 2 illustrates this process:

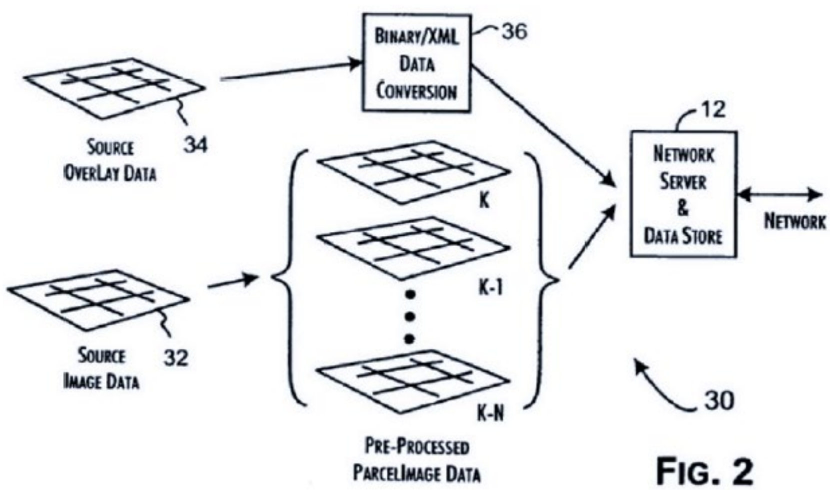


FIG. 2

'343 patent, Fig. 2.

The preferred embodiment also includes a client device on which a user views the images sent by the image server. The user is presented with a 3D field of view (the viewing frustum) of the image, and can use navigational controls to change her view of the image in any direction, modeling fly-over navigation of the image. As the user's field of view changes, a different portion of the image needs to be retrieved from the image server and displayed in high resolution. To do so, the client device determines the priority of the image parcels to be requested from the server based on the user's field of view and requests the image parcels from the image server. The image parcel requests are placed in a queue and issued in priority order. In the preferred embodiment, the image data is then transmitted from the image server to the client device using the TCP/IP network protocol, with each network packet containing one image parcel.

Request priority may be based on the resolution of image parcels such that, "[i]n general, image parcels with lower resolution levels will accumulate greater priority values." '343 patent col. 10 ll. 6–8. This priority "generally assures that a complete image of at least low resolution will be available for rendering." *Id.* col. 10 ll. 12–14. Closer to the user's viewpoint, however, higher-resolution image parcels are prioritized, rendering the portion of the image that the user is actively observing at a higher level of detail. *Id.* col. 10 ll. 15–21.

The shared written description explains that this method optimizes image delivery and display, while minimizing network latency, and solves the problem in the prior art of transmitting large-scale images over networks with lower bandwidth connections. According to the shared written description, "[s]uch limited bandwidth conditions may exist due to either the direct technological constraints dictated by the use of a low bandwidth data channel or indirect constraints imposed on relatively high-bandwidth channels by high concurrent user loads." '343 patent col. 3 ll. 9–14. The shared written description further states that the claimed invention "provide[s] an efficient system and methods of optimally presenting image data on client systems with potentially limited processing performance, resources, and communications bandwidth." *Id.* col. 3 ll. 40–44.

The term "limited bandwidth communications channel" is at issue on appeal. Independent claim 13 of the '343 patent is representative. It recites:

13. A display system for displaying a large-scale image retrieved over a limited bandwidth communications channel, said display system comprising:

> a display of defined screen resolution for displaying a defined image;
>
> a memory providing for the storage of a plurality of image parcels displayable over respective portions of a mesh corresponding to said defined image;
>
> a communications channel interface supporting the retrieval of a defined data parcel over a limited bandwidth communications channel;
>
> a processor coupled between said display, memory and communications channel interface, said processor operative to select said defined data parcel, retrieve said defined data parcel via said limited bandwidth communications channel interface for storage in said memory, and render said defined data parcel over a discrete portion of said mesh to provide for a progressive resolution enhancement of said defined image on said display; and
>
> a remote computer, coupled to the limited bandwidth communications channel, that delivers the defined data parcel wherein delivering the defined data parcel further comprises processing source image data to obtain a series $K_{1\text{-}N}$ of derivative images of progressively lower image resolution and wherein series image $K_0$ being subdivided into a regular array wherein each resulting image parcel of the array has a predetermined pixel resolution wherein image data

> has a color or bit per pixel depth representing a data parcel size of a predetermined number of bytes, resolution of the series $K_{1\text{-}N}$ of derivative images being related to that of the source image data or predecessor image in the series by a factor of two, and said array subdivision being related by a factor of two such that each image parcel being of a fixed byte size, wherein the processing further comprises compressing each data parcel and storing each data parcel on the remote computer in a file of defined configuration such that a data parcel can be located by specification of a $K_D$, X, Y value that represents the data set resolution index D and corresponding image array coordinate.

’343 patent col. 12 l. 38–col. 13 l. 10.

Claim 15 of the ’343 patent, which depends from claim 13, describes prioritization. It recites:

> 15. The display system of claim 13, wherein said processor is operative to prioritize the retrieval of said data parcel among a plurality of selected data parcels pending retrieval, wherein the relative priority of the data parcel is based on the difference in the resolution of the image parcel and the resolution of said plurality of selected data parcels.

*Id.* col. 13 ll. 16–21.

The claimed step of “associating a prioritization value” is at issue on appeal. Claim 10 of the ’343 patent, which depends from claim 1, is representative. Together, these claims recite:

> 1. A method of retrieving large-scale images over network communications channels for display on a

> limited communication bandwidth computer device, said method comprising:
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> > issuing, from a limited communication bandwidth computer device to a remote computer, a request for an update data parcel wherein the update data parcel is selected based on an operator controlled image viewpoint on the computer device relative to a predetermined image and the update data parcel contains data that is used to generate a display on the limited communication bandwidth computer device
>
> . . . .
>
> 10. The method of claim 1, wherein issuing the request for an update data parcel further comprises preparing the request by associating a prioritization value to said request, wherein said prioritization value is based on the resolution of said update data parcel relative to that of other data parcels previously received by the limited communication bandwidth computer device, and wherein issuing said request is responsive to said prioritization value for issuing said request in a predefined prioritization order.

*Id.* col. 11 ll. 24–34, col. 12 ll. 22–30.

The claimed step of "queuing the update data parcels on the remote computer based on an importance of the update data parcel as determined by the remote computer" is at issue on appeal. Claim 6 of the '506 patent, which depends from claim 1, is representative. Together, these claims recite:

> 1. A method of retrieving large-scale images over network communications channels for display on a

limited communication bandwidth computer device, said method comprising:

> . . .
>
> processing, on the remote computer, source image data to obtain a series $K_{1\text{-}N}$ of derivative images of progressively lower image resolution and wherein series image $K_0$ being subdivided into a regular array wherein each resulting image parcel of the array has a predetermined pixel resolution wherein image data has a color or bit per pixel depth representing a data parcel size of a predetermined number of bytes, resolution of the series $K_{1\text{-}N}$ of derivative images being related to that of the source image data or predecessor image in the series by a factor of two, and said array subdivision being related by a factor of two such that each image parcel being of a fixed byte size;

. . . .

6. The method of claim 1, wherein processing the source image data further comprises queuing the update data parcels on the remote computer based on an importance of the update data parcel as determined by the remote computer.

’506 patent col. 12 ll. 29–52, col. 13 ll. 14–17.

## II. Prior Art References

### A. Reddy

Reddy[2] discloses a system for optimizing network delivery and "visualization of near photorealistic 3D models of terrain that can be on the order of hundreds of gigabytes." J.A. 1204 ¶ 2. As Reddy explains, "[t]he time required to download and render such a model would prohibit any real-time interaction using the current generation of [Virtual Reality Modeling Language ("VRML")[3]] browsers. It therefore becomes essential to manage level of detail (LOD)." J.A. 1205 ¶ 12. To accomplish this, Reddy discloses dynamically adjusting the terrain model's LOD (i.e., resolution) based on factors such as distance from the user's viewpoint and screen size. J.A. 1205 ¶¶ 12–13. Reddy uses a view-dependent image simplification algorithm where sections of the terrain image (or tiles) of varying resolution are subdivided "using a hierarchical data structure, such as a quad-tree," which can be represented as a tiled pyramid. J.A. 1206 ¶ 14. In other words, "[a] tile at a given pyramid level will thus map onto four tiles [of higher resolution] on the next higher level" and "at each higher resolution area, the tiles cover half the geographical area of the previous level." *Id.* ¶ 15. Reddy explains that this approach optimizes image data transfer over networks because it does "not require access to the entire high-resolution version of the [image]" at once. *Id.* ¶¶ 14, 17. Instead, image data is loaded only "for the region that the user is viewing, and only at a sufficient resolution for the

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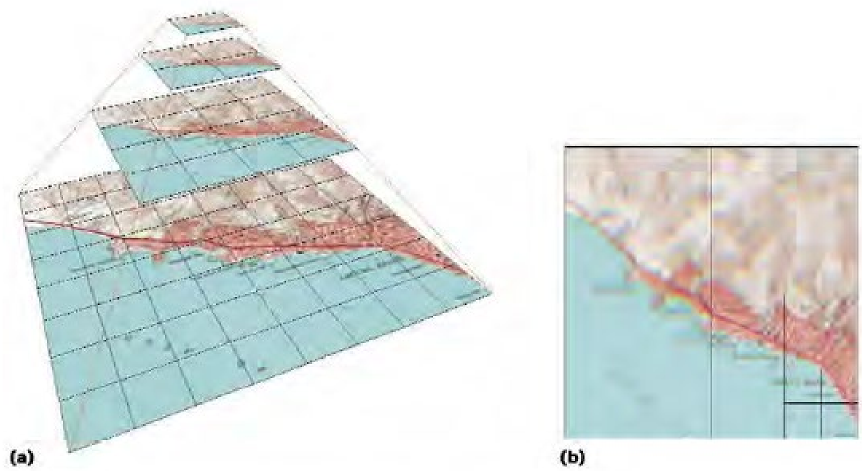
[2] Martin Reddy et al., *TerraVision II: Visualizing Massive Terrain Databases in VRML*, 19 IEEE Computer Graphics & Applications, March/April 1999, at 30 ("Reddy").

[3] VRML defines a standard file format for representing 3D interactive graphics and was designed to work over the Internet. *See* J.A. 2530.

user's viewpoint." *Id.* ¶ 17. Reddy's Figure 1 illustrates its pyramid representation:



*Id.* Fig. 1

To implement the tiled pyramid structure, Reddy's system initially loads a single low-resolution image tile at the top of the pyramid. J.A. 1207 ¶ 19. Once the system determines that a user's viewpoint is approaching, that image tile is replaced with four higher-resolution image tiles. As the user's viewpoint approaches even closer to any one of these four tiles, this process continues until the maximum resolution image tile is loaded.

Reddy discloses two embodiments of its system. The first uses a standard VRML browser for downloading images over the World Wide Web using JavaScript and Java applets running in the browser to "extend VRML's base functionality . . . to offer application-specific management of the virtual geographic environment." J.A. 1205 ¶¶ 9, 10. The standard VRML browser is implemented via a VRML plug-in for common Internet browsers, such as Internet Explorer. J.A. 1209–10 ¶ 31. A Java applet communicates with the VRML plug-in, allowing for access to and modification of any part of the VRML scene, as well as easy traversal from one image data set of the loaded terrain to another. J.A. 1210 ¶¶ 32–33.

Reddy's second embodiment centers on a custom terrain visualization browser named TerraVision II. This custom browser can browse standard VRML data structures, but provides several advantageous features not found in off-the-shelf VRML browsers. J.A. 1205 ¶ 9; J.A. 1211 ¶¶ 40–46. These additional features include, in relevant part, (1) maintaining a low-resolution copy of the terrain image on the client device; (2) using a coarse-to-fine image loading algorithm to load new image data, such that lower-resolution image data is displayed until higher-resolution data becomes available; and (3) using a prediction algorithm to predict the user's viewing path of the image and pre-fetch portions of the image data along that path to enable immediate rendering. J.A. 1211 ¶¶ 40–46.

Reddy discloses that Terra Vision II is generally designed to be used on high-end graphic workstations and over high-speed network connections, such as "a gigabit-per-second [Asynchronous Transfer Mode ('ATM')] network with high-speed disk servers for fast response times." *Id.* ¶ 48. Reddy states, however, that Terra Vision is not limited to only such environments, but "can also be implemented on a PC connected to the Internet, or a standard VRML browser on a laptop machine can be used to browse the same data." *Id.*

B. Hornbacker

PCT Publication No. WO 99/41675 ("Hornbacker") discloses a computer network server that provides image data to client workstations for display using graphical web browsers. J.A. 1169, Abstract. Hornbacker solves network and system performance problems when accessing large image files by "tiling the image view so that computation and transmission of the view data can be done in an incremental fashion." *Id.* The tiles are cached on the client workstation and the server to reduce network traffic and view tile computation time. *Id.* Hornbacker discloses that by tiling and caching, "relatively small amounts of data need to be transmitted when the user selects a new view of an image already received and viewed." J.A. 1183, ll. 17–21. Hornbacker explains that "tiling also allows the image view server to effectively pre-compute view tiles that may be required by the next view request. . . . [by] comput[ing] view tiles that surround the most recent view request in anticipation [of] a request for a shifted view." J.A. 1177, ll. 26–29.

III. Proceedings Before the Board

Microsoft Corporation ("Microsoft") petitioned the Patent Trial and Appeal Board ("the Board") for *inter partes* review of claims 1–20 of the '343 patent and claims 1–21 of the '506 patent.[4] *See Microsoft Corp. v. Bradium Techs. LLC*, IPR2016-00448, 2017 WL 3142423, at *1 (P.T.A.B. July 24, 2017) ("*448 FWD*"); *Microsoft Corp. v. Bradium Techs. LLC*, IPR2016-00449, 2017 WL 3206576, at *1 (P.T.A.B. July 26, 2017) ("*449 FWD*"). The Board instituted both *inter partes* review proceedings on the single asserted ground: obviousness under 35 U.S.C. § 103(a) over Reddy in view of Hornbacker. *448 FWD*, 2017 WL 3142423, at *3; *449 FWD*, 2017 WL 3206576, at *1.

Prior to institution, neither party sought construction for any of the claim terms relevant to this appeal, and the Board instituted review in both proceedings without construing any of these terms. *448 FWD*, 2017 WL 3142423, at *3; *449 FWD*, 2017 WL 3206576, at *3. After institution, Bradium proposed a construction for the term "limited bandwidth communications channel," seeking to limit its meaning to "a wireless or narrowband communications

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[4] After Bradium filed this appeal, Bradium and Microsoft settled their dispute. Microsoft is thus no longer participating in the appeal.

channel." Microsoft argued that no express construction was needed. In its final written decisions, the Board rejected Bradium's proposed construction and adopted the term's plain and ordinary meaning, which it concluded was "a communications channel whose bandwidth is limited." *448 FWD*, 2017 WL 3142423, at *4; *449 FWD*, 2017 WL 3206576, at *4. The Board noted that experts on both sides agreed "limited bandwidth" and "narrowband" were synonymous, and explained that the term was not limited to a wireless channel, nor did the term imply a specific cause for the bandwidth limitation (e.g., that the channel's bandwidth must be limited by technological constraints). *448 FWD*, 2017 WL 3142423, at *4; *449 FWD*, 2017 WL 3206576, at *4. The Board did not expressly construe any other claim terms relevant to this appeal.

In assessing the patentability of the claims, the Board determined that Reddy alone or Reddy in view of Hornbacker discloses all of the disputed claim limitations. The Board first found that Reddy discloses the "limited bandwidth communications channel" limitation of both the '343 and '506 patents. Specifically, the Board found that Reddy expressly discloses that its TerraVision II system did not require a broadband connection, but could "also be implemented on a PC connected to the Internet." *448 FWD*, 2017 WL 3142423, at *9, *22; *449 FWD*, 2017 WL 3206576, at *10, *25. The Board further found that even if TerraVision II was limited to a broadband connection, Reddy discloses that "a standard VRML browser on a laptop machine can be used to browse the same data," and that "TerraVision II is not required to view the VRML terrain data sets; it simply increases browsing efficiency." *448 FWD*, 2017 WL 3142423, at *9; *449 FWD*, 2017 WL 3206576, at *10. The Board explained that its construction of this term was not limited to a wireless channel and found that Reddy's disclosure of using image tiling techniques "to access and visualize terrain data from a client on a laptop in military or emergency response scenarios teaches or suggests" the claimed limited bandwidth communications channel. *448 FWD*, 2017 WL 3142423, at *9; *449 FWD*, 2017 WL 3206576, at *10.

The Board also found that some of TerraVision II's features "could be implemented for a standard VRML browser through the use of various Java scripts embedded in the scene, or running externally to the browser."[5] *448 FWD*, 2017 WL 3142423, at *9; *449 FWD*, 2017 WL 3206576, at *10. The Board rejected Bradium's argument that Reddy teaches away from using a standard VRML browser. It found that, to the contrary, "the key feature disclosed in Reddy that enables real-time interactions (even over the World Wide Web link) is the view dependent level of detail techniques," which do not need to "operate only on high speed network connections," and which specifically enable Reddy's system to be implemented on a standard VRML browser. *448 FWD*, 2017 WL 3142423, at *22; *449 FWD*, 2017 WL 3206576, at *25.

Next, the Board determined that Reddy discloses the "prioritization" limitations of the '343 patent by teaching two levels of prioritizing higher-resolution image tiles over

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[5] The Board cited to a contemporaneous webpage created by the developers of TerraVision II and submitted by Bradium as an exhibit to its Patent Owner Response. *448 FWD*, 2017 WL 3142423, at *9; *449 FWD*, 2017 WL 3206576, at *9–10; Appellant's Op. Br. 19 n.1; J.A. 4896–901; SRI Int'l, *Visualization System for SRI's Digital Earth Proposal*, Digital Earth (Apr. 16, 1999 11:21:17 AM), http://www.ai.sri.com/digital-earth/proposal/visualization-system.html ("Digital Earth webpage"). The Board relied on this webpage to inform its analysis of how a person of ordinary skill in the art would interpret Reddy at the time of the invention. *448 FWD*, 2017 WL 3142423, at *9; *449 FWD*, 2017 WL 3206576, at *9–10; Appellant's Op. Br. 19 n.1.

lower-resolution ones. Specifically, it found that Reddy discloses the claimed prioritization based on image resolution by teaching that higher-resolution image tiles are requested over lower-resolution ones when a user crosses a proximity threshold. *448 FWD*, 2017 WL 3142423, at *18. The Board also found that Reddy's disclosure of pre-fetching higher resolution image tiles along a user's predicted path instead of lower-resolution images tiles further away from the user's path similarly taught the claimed prioritization. *Id.*

The Board also determined that Reddy in view of Hornbacker discloses the claimed "queuing the update data parcels on the remote computer based on an importance of the update data parcel as determined by the remote computer" limitation of the '506 patent. *449 FWD*, 2017 WL 3206576, at *21. Specifically, the Board found that Reddy's coarse-to-fine algorithm ranked image tiles based on their importance because it loaded higher-resolution tiles proximate to the user's viewpoint ahead of lower-resolution tiles further away from the viewed location. *Id.* at *20. The Board further found that Hornbacker discloses an image server that determines the importance of image tiles because it precomputes image tiles in anticipation of future requests for those tiles based on the client's past requests, thus queuing the tiles based on its computation of importance. *Id.* at *21.

The Board thus determined that Microsoft had shown by a preponderance of the evidence that the claims of the '343 and '506 patents are obvious in light of Reddy and Hornbacker. Bradium appeals. We have jurisdiction pursuant to 28 U.S.C. § 1295(a)(4)(A).

## DISCUSSION

Bradium challenges both the Board's claim construction and its conclusions regarding obviousness under 35 U.S.C. § 103. We address each issue in turn.

## I. Claim Construction

We review the Board's ultimate claim construction de novo and any subsidiary factual findings involving extrinsic evidence for substantial evidence. *AC Techs. S.A. v. Amazon.com, Inc.*, 912 F.3d 1358, 1365 (Fed. Cir. 2019) (citing *Teva Pharm. USA, Inc. v. Sandoz, Inc.*, 135 S. Ct. 831, 841 (2015)). A factual finding is supported by substantial evidence if a reasonable mind might accept the evidence to support the finding. *Polaris Indus., Inc. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1064 (Fed. Cir. 2018).

Claim construction seeks to ascribe to claim terms the meaning a person of ordinary skill in the art at the time of invention would have given them. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–14 (Fed. Cir. 2005) (en banc). In these IPR proceedings, unexpired claims are given their broadest reasonable interpretation ("BRI") in light of the record evidence and the understanding of a person of ordinary skill in the pertinent art.[6] *AC Techs.*, 912 F.3d at 1365; *In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1279 (Fed. Cir. 2015) (en banc), *aff'd*, 136 S. Ct. 2131 (2016). In construing terms, "the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the

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[6] The United States Patent and Trademark Office has since revised its claim construction standard. *See* 83 Fed. Reg. 51,340, 51,358 (Oct. 11, 2018) (codified at 37 C.F.R. § 42.100(b)). For petitions filed on or after November 13, 2018, the Board construes a claim "in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent," consistent with our *Phillips* decision. 37 C.F.R. § 42.100(b). Because Microsoft filed its petitions before November 13, 2018, we apply the BRI standard pursuant to the prior version of 37 C.F.R. § 42.100(b) in reviewing these proceedings.

context of the entire patent, including the specification." *Phillips*, 415 F.3d at 1313. Indeed, the specification "is the single best guide to the meaning of a disputed term" and "[u]sually, it is dispositive." *Id.* "When the specification 'makes clear that the invention does not include a particular feature, that feature is deemed to be outside the reach of the claims of the patent, even though the language of the claims, read without reference to the specification, might be considered broad enough to encompass the feature in question.'" *Microsoft Corp. v. Multi-Tech Sys., Inc.*, 357 F.3d 1340, 1347 (Fed. Cir. 2004) (quoting *SciMed Life Sys., Inc. v. Advanced Cardiovascular Sys., Inc.*, 242 F.3d 1337, 1341 (Fed. Cir. 2001)). The Board may properly rely on expert testimony "to explain terms of art, and the state of the art, at any given time, but [such testimony] cannot be used to prove the proper or legal construction of any instrument of writing." *Teva*, 135 S. Ct. at 841 (internal quotations omitted).

The Board construed "limited bandwidth communications channel" in both proceedings to have its plain and ordinary meaning of "a communications channel whose bandwidth is limited." *448 FWD*, 2017 WL 3142423, at *4; *449 FWD*, 2017 WL 3206576, at *4. The Board rejected Bradium's proposed construction of "a wireless or narrowband communications channel," explaining that the term does not "imply the cause of the limited bandwidth," and noting that neither patent's specification defined the term. *448 FWD*, 2017 WL 3142423, at *3–4; *449 FWD*, 2017 WL 3206576, at *4. The Board also credited the deposition testimony of the inventor, who admitted that a high number of users could limit the available bandwidth of communications channels. *448 FWD*, 2017 WL 3142423, at *4; *449 FWD*, 2017 WL 3206576, at *4.

On appeal, Bradium argues that the Board's construction is too broad for two reasons. First, Bradium asserts that the Board's construction effectively reads the "limited bandwidth" requirement out of the claims because it covers situations where the channel bandwidth is temporarily limited by high concurrent user load, which Bradium argues can occur with any communications channel. Appellant's Op. Br. 38–39. Second, Bradium asserts that different independent claims in the patents solve different problems identified in the written description—bandwidth limits on a network and limited availability of resources on the client device—and argues that under the Board's construction, there is "no meaningful distinction between claims directed to these different aspects of the invention." Appellant's Reply Br. 6–7.

Bradium contends that under the proper construction, the claimed channel must be "substantially permanently limited in bandwidth due to technical constraints on the channel itself." Appellant's Op. Br. 38–39. In support, Bradium points to the shared written description's disclosure of two separate causes of limited bandwidth conditions: "limited bandwidth conditions may exist due to either the direct technological constraints dictated by the use of a low bandwidth data channel or indirect constraints imposed on relatively high-bandwidth channels by high concurrent user loads." '343 patent col. 3 ll. 9–14.

We disagree with Bradium. The statement from the shared written description on which Bradium relies distinguishes low-bandwidth channels from high-bandwidth ones; it does not state that a *limited* bandwidth communications channel cannot be a high-bandwidth channel. *See id.* In fact, this statement supports the Board's construction because it makes clear that limited bandwidth may result from *either* "the direct technological constraints" on a channel *or* "indirect constraints" such as "high concurrent user loads." *Id.*

This single statement in the written description does not serve as clear indication that the patentee meant to redefine the term "limited bandwidth communications channel" to include a specific cause for the bandwidth limitation (e.g., that the channel's bandwidth must be limited by direct technological constraints). We have previously explained that "[t]o act as its own lexicographer, a patentee must 'clearly set forth a definition of the disputed claim term' other than its plain and ordinary meaning." *Thorner v. Sony Comput. Entm't Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012) (quoting *CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d 1359, 1366 (Fed. Cir. 2002)). "It is not enough for a patentee to simply disclose a single embodiment or use a word in the same manner in all embodiments, the patentee must 'clearly express an intent' to redefine the term." *Id.* (quoting *Helmsderfer v. Bobrick Washroom Equip., Inc.*, 527 F.3d 1379, 1381 (Fed. Cir. 2008)). The single statement describing two causes for limited bandwidth is not a clear and unambiguous definition limiting the term to only one cause, contrary to its plain and ordinary meaning. The written description makes clear that the problem the patentee was attempting to solve existed with both types of bandwidth limitations. *See, e.g.*, '343 patent col. 3 ll. 40–43. We discern no error in the Board's refusal to limit the plain meaning of the term to channels limited by "direct technological constraints," such as wireless technology.

The Board's construction is also consistent with the testimony of the inventor of the '343 and '506 patents. *See Howmedica Osteonics Corp. v. Wright Med. Tech., Inc.*, 540 F.3d 1337, 1347 & n.5 (Fed. Cir. 2008); *Voice Techs. Grp., Inc. v. VMC Sys., Inc.*, 164 F.3d 605, 615 (Fed. Cir. 1999) (explaining that although inventor testimony cannot change the scope of the claims from their meaning at the time of invention, "[a]n inventor is a competent witness to explain the invention and what was intended to be conveyed by the specification and covered by the claims"); *see also AbbVie Inc. v. Mathilda & Terence Kennedy Inst. of Rheumatology Tr.*, 764 F.3d 1366, 1377 (Fed. Cir. 2014) (affirming a claim construction that was supported by the intrinsic evidence and the inventor's testimony). In the course of his testimony about the meaning of a term used in his declaration, the inventor testified that the invention operated in a technical environment allowing streaming of image data "over a limited communication such as dial up or wireless," and that this bandwidth limitation "can be inherent in the communication itself like latency or can be limited by the amount of users," but the invention could still "allow full movement mobility." J.A. 3135 (40:22–41:10). Bradium attempts to explain this testimony away as a description of only one commercial product, not an opinion on the scope of the invention. *See* Appellant's Op. Br. 40. Reading the testimony in context shows otherwise. The inventor described the claimed invention as "something that embodied everything we developed since 1999," and not merely one product. J.A. 3135 (40:22–41:6, 41:16–22). The Board relied on this testimony to understand the particular meaning the term "limited bandwidth communications channel" had to a person of ordinary skill in the art at the time of invention. This factual finding supports the Board's legal determination that, in the context of the '343 and '506 patents, the term has its plain and ordinary meaning. *See Teva*, 135 S. Ct. at 841.

Bradium's second argument distinguishing the problems allegedly solved by different independent claims fares no better. Instead of a channel, claim 1 of the '343 patent is directed to "[a] method of retrieving large-scale images over network communications channels for display on a limited communication bandwidth computer device." '343 patent col. 11 ll. 24–26. We discern no reason why the Board's construction of "limited bandwidth communications channel" would prevent a device displaying such images retrieved according to this claimed method from having limited bandwidth. Additionally, Bradium admitted to the Board that such devices "are frequently constrained by limited bandwidth conditions," which according to Bradium, include "high concurrent user load (cellular towers potentially servicing multiple users)."

J.A. 572. That the same causes of bandwidth limits may affect both limited bandwidth communications channels and limited communication bandwidth devices only supports the conclusion that the Board's construction is reasonable under the BRI standard.

In light of the foregoing, we conclude that the Board did not err in construing the term "limited bandwidth communications channel" to mean "a communications channel whose bandwidth is limited," as this construction follows the claim's plain language read in light of the written description.

II. Obviousness Under 35 U.S.C. § 103

Obviousness is a question of law with underlying factual findings relating to the scope and content of the prior art, differences between the prior art and the claims at issue, the level of ordinary skill in the pertinent art, the presence or absence of a motivation to combine or modify with a reasonable expectation of success, and any objective indicia of non-obviousness. *Acorda Therapeutics, Inc. v. Roxane Labs., Inc.*, 903 F.3d 1310, 1328 (Fed. Cir. 2018) (citing *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007)); *Ariosa Diagnostics v. Verinata Health, Inc.*, 805 F.3d 1359, 1364 (Fed. Cir. 2015). As with claim construction, we review the Board's factual findings for substantial evidence and the Board's legal conclusion on obviousness de novo. *Amerigen Pharm. Ltd. v. UCB Pharma GmbH*, 913 F.3d 1076, 1086 (Fed. Cir. 2019).

Bradium argues that the Board erred in its obviousness analysis because Reddy, alone or in combination with Hornbacker, fails to disclose four features of the claimed invention: (1) the "limited bandwidth communications channel" limitation; (2) prioritization based on resolution among image tiles selected for and pending retrieval as claimed in claim 15 of the '343 patent; (3) prioritization based on a prioritization value as claimed in claims 10 and 11 of the '343 patent; and (4) queuing update data parcels on the remote computer based on their importance as recited in claims 6, 13, and 20 of the ’506 patent. We address each argument in turn.

A. “Limited Bandwidth Communications Channel”

In this case, the question of whether a “limited bandwidth communications channel” limitation is taught in the prior art turns on whether Reddy discloses that its TerraVision II system, or a standard VRML browser embodying the relevant features of TerraVision II, can operate over a limited bandwidth communications channel. Bradium argues that Reddy’s TerraVision II browser was designed to be used exclusively with high-speed broadband networks and therefore cannot support the Board’s findings. Bradium points to Reddy’s disclosure that TerraVision II can operate on a high-speed network or on a PC connected to the Internet, both of which it characterizes as “high-bandwidth situations,” and contrasts that with Reddy’s disclosure of a laptop that runs only the standard VRML browser “for lower-bandwidth” needs. Appellant’s Op. Br. 42, 45.

Bradium also argues that Reddy’s standard VRML browser embodiment provides no support for the Board’s findings because it does not include the relevant features of TerraVision II (i.e., coarse-to-fine and predict-and-prefetch algorithms) on which the Board relied in its obviousness analysis. Bradium contends that a person of ordinary skill in the art would not have been motivated to modify the standard VRML browser to include these relevant features of TerraVision II because Reddy teaches away from implementing these features over a non-broadband connection by disclosing that these features would “run unacceptably slowly” in such situations. Appellant’s Op. Br. 43–44. In support, Bradium cites to a declaration of its expert submitted with its Patent Owner Response in IPR2016-00449. In that declaration, Bradium’s expert pointed to Reddy’s discussion of a related project to develop a 3D model of the

Monterey Bay National Marine Sanctuary ("Monterey Bay Project"), and argued that this related project proved that using multi-resolution tiling techniques, like the ones disclosed in Reddy, over a low-bandwidth network would be too slow to be practical.

We agree with the Board that both of Reddy's embodiments disclose the claimed "limited bandwidth communications channel" limitation. First, Reddy's TerraVision II browser meets this limitation. Bradium's arguments to the contrary presuppose that the Board's construction of this term was erroneous, and that the correct construction of the term must exclude broadband communications channels. As we explained above, however, the Board correctly construed the term to have its plain and ordinary meaning of "a communications channel whose bandwidth is limited," which does not exclude broadband communications channels that can have limited bandwidth due to high concurrent user load. Therefore, even if TerraVision II only operates over broadband networks, Reddy still discloses this limitation under the proper construction of the term.

In any case, the Board found that Reddy's TerraVision II is not limited to broadband networks, and substantial evidence supports that finding. Reddy discloses that TerraVision II "can also be implemented on a PC connected to the Internet." J.A. 1211 ¶ 48. Although Bradium assumes that a PC connected to the Internet is a "high-bandwidth situation[]," it provides no support for that assumption, and we find none in Reddy. Reddy distinguishes the implementation of TerraVision II on a PC connected to the Internet from one where a high-speed "gigabit-per-second ATM network with high-speed disk servers" is used. *Id.*

Further, the Board did not rely exclusively on Reddy's TerraVision II embodiment for its findings. The Board also pointed to Reddy's teachings that "Terra Vision II is not required to view the VRML terrain data sets; it simply increases browsing efficiency," and that "[a]ny standard

VRML browser can interact with these data." *Id.* ¶ 47. As there is no dispute that a standard VRML browser can operate over lower-bandwidth communications channels, *see* Appellant's Op. Br. 42, the above-described uses support the Board's finding that Reddy discloses the claimed limitation.

The Board was also correct to reject Bradium's argument that Reddy teaches away from modifying a standard VRML browser with TerraVision II's features. A prior art reference teaches away if it "criticize[s], discredit[s], or otherwise discourage[s] the solution claimed." *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004). Reddy discloses that its "implementation uses Java scripting to extend VRML's base functionality." J.A. 1205 ¶ 10. Bradium's own Digital Earth webpage exhibit, which describes the operation of Reddy's TerraVision II system, also explains that using javascript and Java applet techniques allows for "encapsulat[ion of] much of the Digital Earth functionality into a standard VRML application." J.A. 4899. The webpage goes on to state that some of TerraVision II's features "could be implemented for a standard VRML browser through the use of various Java scripts embedded in the scene, or running externally to the browser." *Id.* Thus, instead of teaching away from implementing TerraVision II's features on a standard VRML browser, both Reddy and the Digital Earth webpage encourage such implementation, particularly for military and emergency environments where the available bandwidth may be limited. The Board's finding that Reddy's "view dependent level of detail techniques" is its key feature that specifically enabled implementing Reddy's system on a standard VRML browser only supports this conclusion. As the Board explained, nothing in these techniques "implicates or specifies the speed or bandwidth of the communication connection over which the techniques are designed to operate." *448 FWD*, 2017 WL 3142423, at *22; *449 FWD*, 2017 WL 3206576, at *25.

Bradium's expert's reliance on the related Monterey Bay Project for support is misplaced. Reddy discloses that the Monterey Bay Project "uses multiresolution techniques to deliver these large data amounts over a 28K modem connection." J.A. 1204. Bradium conceded in its Patent Owner Response in IPR2016-00448 that "narrowband or otherwise limited bandwidth communications channel[s] . . . . generally include non-broadband communications channels, such as [a] wired dial-up connection, which was a common consumer-level communications channel in 1999." J.A. 568. Thus, rather than supporting Bradium's teaching away argument, the Monterey Bay Project demonstrates that the type of multiresolution image delivery techniques that Reddy discloses can be used over limited bandwidth communications channels, such as dial-up connections.

In light of the foregoing, we hold that substantial evidence supports the Board's determination that Reddy discloses the claimed limited bandwidth communications channel.

### B. Claim 15 of the '343 Patent

Claim 15 of the '343 patent requires prioritization of image data parcels "among a plurality of selected data parcels pending retrieval . . . based on the difference in the resolution." '343 patent col. 13 ll. 16–21. Bradium argues on appeal that the Board erred by relying on Reddy's disclosure to meet these limitations because Reddy only discloses prioritization between currently requested image tiles and those previously retrieved, and does not disclose prioritization based on resolution. Appellant's Op. Br. 50–52.

We need not reach the merits of these arguments because Bradium waived them by failing to present them to the Board. Instead, Bradium argued to the Board only that

Reddy did not teach prioritization at all.[7] For example, Bradium asserted in its Patent Owner Response in IPR2016-00448 that TerraVision II's coarse-to-fine algorithm "does not teach or disclose prioritization," that Reddy's "[d]istance-based LOD . . . . is not prioritization of requests for tiles," and that Reddy's pre-fetching "discloses nothing about the order of tile retrieval." J.A. 587–88. Bradium further asserted that "TerraVision II is silent as to any other form of prioritization," and that "Hornbacker does not disclose prioritization of retrieval of tiles at all." J.A. 588–89. Lastly, in distinguishing claim 15 from claim 10, Bradium argued that claim 15 "merely require[s] the use of priority without associating prioritization values." J.A. 592.

Bradium contends that it preserved its more particularized arguments, citing to the transcript of the oral hearing before the Board for support. Appellant's Reply Br. 21–22. During the hearing, however, Bradium only argued that neither prior art reference discloses prioritization. For example, Bradium's counsel stated that Reddy's coarse-to-fine algorithm is "not a prioritization by the system for retrieval," that "[d]istance-based LOD has nothing to do with prioritization," and that pre-fetching "assumes the missing [prioritization] element." J.A. 1092–96. Bradium's counsel also argued that Hornbacker's pre-calculation does not teach prioritization because "[p]re-calculation is completely different from the . . . handling of tile requests." J.A. 1097. Nothing in these statements suggests that

[7] The heading of this section of Bradium's Patent Owner Response and the section's first paragraph referred to the lack of prioritization based on resolution. J.A. 586–87. Bradium's arguments in this section, however, focused exclusively on its contention that neither prior art reference discloses prioritization in any form. *See* J.A. 586–90.

Bradium preserved the arguments that it now raises on appeal.

Because Bradium failed to argue to the Board that neither Reddy nor Hornbacker disclose prioritization of image tiles among those selected and pending retrieval, or prioritization based on resolution, we conclude that those arguments are waived.

C. "Associating a Prioritization Value"

Claims 10 and 11 of the '343 patent depend on claim 1, and claim the additional step of "preparing the request by associating a prioritization value to said request" for image data. '343 patent col. 12 ll. 22–33. It is undisputed that neither Reddy nor Hornbacker expressly disclose a specific prioritization value associated with a request. Appellant's Op. Br. 47–48; Appellee's Br. 26. Instead, the question here is whether Reddy's teaching of prioritizing certain image tiles over others discloses to a person of ordinary skill in the art that a prioritization value is used.[8] We agree with the Board that it does.

Bradium argues that because the prior art references on which the Board relied do not explicitly disclose a distinct prioritization value associated with a request, the Board implicitly construed the claim term to not require this value, and read it out of the claim. Bradium asserts that association of a distinct value to a request "is not inherent in issuing sequenced requests," and the general

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[8] Bradium states that the Board found this claim limitation obvious based on "the combination of Reddy and Hornbacker." Appellant's Op. Br. 47. The Board, however, relied solely on Reddy in its obviousness analysis of this claim limitation. *See 448 FWD*, 2017 WL 3142423, at *17–19.

concept of prioritization does not necessarily require the use of a prioritization value. Appellant's Op. Br. 48.

The claims require prioritization, however, not sequencing, and Bradium fails to explain how prioritization implemented on a computer can be accomplished without associating some value with a request to track its priority.[9] The Board found that Reddy's TerraVision II includes coarse-to-fine and predict-and-pre-fetch algorithms, both of which prioritize some image tiles over others—the first by prioritizing delivery of higher resolution tiles over lower ones once a user crosses a proximity threshold, and the second by prioritizing image tiles along a user's predicted flight path over others. *448 FWD*, 2017 WL 3142423, at *18. We agree with the Board that both algorithms require that some tiles have higher priority than others, and this would fairly suggest to a person of ordinary skill in the art that a prioritization value is thus associated with requests for these tiles. *See In re Baird*, 16 F.3d 380, 383 (Fed. Cir. 1994) ("[A] reference must be considered not only for what it expressly teaches, but also for what it fairly suggests." (alteration in original)); *In re Aslanian*, 590 F.2d 911, 914 (CCPA 1979) (explaining that in determining obviousness, all references are assessed "on the basis of what they reasonably disclose and suggest to one skilled in the art" (quoting *In re Baum*, 374 F.2d 1004, 1009 (CCPA 1967))).

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[9] Bradium also asserts that the Board did not rely on a finding that prioritizing requests would inherently require associating a prioritization value to each request. Appellant's Reply Br. 18. Bradium is mistaken. The Board found that TerraVision II's "two levels of priority"—its coarse-to-fine and predict-and-pre-fetch algorithms—are implementations of the claimed "prioritization value based on the resolution of the update parcel relative to parcels previously received." *448 FWD*, 2017 WL 3142423, at *18.

Bradium's contention that the claims require "a particular value" is not convincing. The claim language requires only a prioritization value, not a *particular* prioritization value. To the extent Bradium is attempting to read into the claims the prioritization value function disclosed in the written description, it is long-settled that even though "claims must be read in light of the specification of which they are a part, it is improper to read limitations from the written description into a claim." *Wenger Mfg., Inc. v. Coating Mach. Sys., Inc.*, 239 F.3d 1225, 1237 (Fed. Cir. 2001) (citing *Tate Access Floors, Inc. v. Maxcess Techs., Inc.*, 222 F.3d 958, 966 (Fed. Cir. 2000)).

In light of the foregoing, we conclude that substantial evidence supports the Board's finding that Reddy discloses the claimed step of "associating a prioritization value" with a request for image data.

D. "Queuing the Update Data Parcels on the Remote Computer Based on an Importance"

Dependent claims 6, 13, and 20 of the '506 patent claim the step of "queuing the update data parcels on the remote computer based on an importance of the update data parcel as determined by the remote computer." '506 patent col. 13 ll. 14–17, col. 14 ll. 14–17, col. 15 ll. 16–20.[10] The question here is whether the combination of Reddy and Hornbacker discloses this limitation. We agree with the Board that it does.

Bradium argues that neither of Reddy's coarse-to-fine or predict-and-pre-fetch algorithms can satisfy the claimed limitation because neither algorithm ranks the importance of image tiles among those requested in a single request. Appellant's Op. Br. 53–54. Bradium further contends that

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[10] The claimed "remote computer" refers to a server that sends image data in response to requests by a client device. Appellant's Op. Br. 54; Appellee's Br. 30.

these two algorithms fail to disclose this limitation because they are part of Reddy's TerraVision II system that resides on the client, not on the "remote computer." *Id.* at 54. With respect to Hornbacker, Bradium argues that the Board failed to articulate how pre-computation of image tiles satisfies the queuing step because the image tiles are selected "when a particular view is requested." *Id.* To the contrary, substantial evidence supports a finding that Reddy in view of Hornbacker discloses this limitation.

As discussed above, Reddy discloses that as a user's viewpoint approaches a particular location on the image, higher-resolution image tiles are loaded and sent to the client device instead of lower-resolution ones. Bradium conceded this before the Board. *See 449 FWD*, 2017 WL 3206576, at *20 (noting that Bradium conceded that when Reddy's coarse-to-fine algorithm is used, "higher-resolution tiles are . . . loaded based on proximity of the user to the location" (emphasis omitted)). Relying on expert testimony, the Board also found that queues are "ubiquitous data structures in computer science" that would be used to rank by importance. *Id.* Applying the same analysis, the Board determined that Reddy's predict-and-pre-fetch algorithm similarly discloses ranking and queueing based on importance because the algorithm pre-fetches higher-resolution image tiles "based on proximity of the users to the tiles" (i.e., the higher-resolution tiles along a user's flightpath are ranked as more important than lower-resolution ones further away). Thus, substantial evidence supports the Board's findings that Reddy's coarse-to-fine and predict-and-prefetch algorithms disclose that higher-resolution image tiles are ranked as more important than lower-resolution ones and are queued for transmission to the client device. *Id.*

Bradium's arguments with respect to Reddy's TerraVision II system residing locally are similarly unavailing. The Board determined that Hornbacker discloses a remote server that computes the importance of image tiles based on previous requests and queues them for delivery to the client device once the predicted view is requested. *Id.* at *20–21. Bradium asserts that this determination is erroneous because Hornbacker's server lacks the information needed to make an importance determination concerning any given tile. We disagree.

Hornbacker discloses that its "background view composer computes view tiles that *surround the most recent view request* in anticipation [of] a request for a shifted view." J.A. 1177, ll. 27–29 (emphasis added). Thus, Hornbacker's background view composer, which is located on its server, possesses sufficient information and makes determinations on the importance of a given tile.

The remainder of Bradium's arguments concerning this claim limitation lack merit because they attack the disclosures of the two references individually. A finding of obviousness, however, cannot be overcome "by attacking references individually where the rejection is based upon the teachings of a combination of references." *In re Merck & Co.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986) (citing *In re Keller*, 642 F.2d 413, 425 (CCPA 1981)).

In light of the foregoing, we conclude that substantial evidence supports the Board's finding that Reddy in view of Hornbacker discloses the claimed step of "queuing the update data parcels on the remote computer based on an importance of the update data parcel as determined by the remote computer."

## CONCLUSION

We have considered Bradium's remaining arguments but find them unpersuasive. We hold that the Board correctly construed "limited bandwidth communications channel" in both proceedings to mean "a communications channel whose bandwidth is limited," and that substantial evidence supports the Board's obviousness determinations. Therefore, the Board's decisions finding that the challenged claims of the ’343 and ’506 patents are invalid as obvious are affirmed.

**AFFIRMED**

COSTS

No costs.