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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte KIRAN TATI, RAJESH VENKATASUBRAMANIAN, CARL A. WALDSPURGER, ALEXANDER THOMAS GARTHWAITE, and TONGPIN LIU,

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Appeal 2018-002585
Application 13/760,868
Technology Center 2100

Before JOHN A. JEFFERY, DENISE M. POTHIER, and JUSTIN BUSCH, *Administrative Patent Judges*.

POTHIER, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

Appellants[1,2] appeal under 35 U.S.C. § 134(a) from the Examiner's decision to reject claims 1–20. *See* Appeal Br. 1. Claims 21–24 have been canceled. *Id.* at 21 (Claims App'x). We have jurisdiction under 35 U.S.C. § 6(b). We affirm-in-part.

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[1] Throughout this opinion, we refer to the Final Action (Final Act.) mailed January 9, 2017; the Appeal Brief (Appeal Br.) filed August 9, 2017; the Examiner's Answer (Ans.) mailed November 16, 2017; and the Reply Brief (Reply Br.) filed January 12, 2018.

[2] The real party in interest is listed as VMware, Inc. Appeal Br. 3.

Invention

"Virtual machines (VMs) running in host computers are actively managed to improve their overall performance. One example is live migration of VMs." Spec. ¶ 2. A "[live] migration of a VM involves copying the memory pages of the VM from a source machine to a destination machine, and this process can take . . . minutes. In some implementations, this latency is hidden by using several iterations of pre-copy while the VM is still running." *Id.* ¶ 3. Appellants' invention relates to "[providing] a mapping of guest memory pages to disk blocks that can be used to improve management processes performed on VMs, such as live migration and snapshots." *Id.* ¶ 5. According to the Specification, a VM's virtual machine monitor (VMM) maintains a map that identifies guest physical memory pages whose contents are also in disk blocks of a corresponding virtual disk. *Id.* ¶ 18. For each guest physical memory page, the map provides a mapping to the particular disk block that has the same contents. *Id.*

Independent claim 1 exemplifies the claims at issue and reads as follows:

> 1. A method of selectively transmitting contents of guest physical memory pages of a virtual machine that is running in a host computer and has a virtual disk that is stored in a storage device, as part of a management process carried out by the host computer, said method comprising:
>
> accessing a data structure that provides a mapping of each guest physical memory page in a first set of guest physical memory pages of the virtual machine to a location in the virtual disk having the same contents as the guest physical memory page to determine the guest physical memory pages in the first set; and

> transmitting to a destination (i) contents of each guest physical memory page in a second set of guest physical memory pages of the virtual machine, the second set not including any of the guest physical memory pages in the first set and (ii) the mappings of the guest physical memory pages in the first set but not contents of the guest physical memory pages in the first set.

Appeal Br. 18 (Claims App'x).

The Examiner relies on the following as evidence of unpatentability:

Edouard Bugnion et al., *Disco: Running Commodity Operating Systems on Scalable Multiprocessors*, 15 ACM TRANSACTIONS ON COMPUTER SYS. 412–47 (1997) ("Bugnion").

Carl A. Waldspurger, *Memory Resource Management in VMware ESX Server*, PROC. 5TH SYMP. ON OPERATING SYS. DESIGN AND IMPLEMENTATION 1–14 (2002) ("Waldspurger").

Christopher Clark et al., *Live Migration of Virtual Machines*, 2ND SYMP. ON NETWORKED SYS. DESIGN & IMPLEMENTATION 273–86 (2005) ("Clark").

Emery Berger, *CMPSCI 377 - Operating Systems (Lecture 15)* 15-1–15-2 (Bruno Silva & Jim Partan scribes 2009).

Karen Scarfone et al., *Guide to Security for Full Virtualization Technologies (National Institute of Standards and Technology Special Publication 800-125)* (2011) ("Scarfone").

The Rejections[3]

Claims 1, 2, 4, and 6–9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Clark and Scarfone. Final Act. 9–17.

[3] Because claims 23 and 24 have been canceled, we omit these claims from the rejections, including the lack of written description rejection for claims 23 and 24 (Final Act. 3–5). The Examiner has also withdrawn (Ans. 2) the indefiniteness rejection presented in the Final Action (Final Act. 5–8).

Claims 3 and 10 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Clark, Scarfone, and Waldspurger. Final Act. 18–19.

Claim 5 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Clark, Scarfone, and Bugnion. Final Act. 19–20.

Claims 11–18 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Waldspurger and Berger. Final Act. 20–26.

Claim 19 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Waldspurger, Berger, and Bugnion. Final Act. 27–28.

Claim 20 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Clark. Final Act. 28–30.

THE OBVIOUSNESS REJECTION OVER CLARK AND SCARFONE

Appellants argue claims 1, 2, 4, and 6–9 as a group. *See* Appeal Br. 11–15. We select claim 1 as representative. *See* 37 C.F.R. § 41.37(c)(1)(iv).

Regarding independent claim 1, the Examiner finds Clark teaches many of its limitations, including accessing a data structure that provides a mapping of each guest physical memory page in a first set of guest physical memory pages of a virtual machine. Final Act. 9–10 (citing Clark 280 (§ 5.1, ¶ 3)). Although the Examiner acknowledges that Clark's page table mapping does not map to a virtual disk, the Examiner cites Scarfone in combination with Clark to teach this feature in concluding the claim would have been obvious. *Id.* at 10 (citing Scarfone §§ 2.3.2 ¶¶ 1–2 and 2.3.3 ¶ 1).

Appellants assert Clark's live migration of VMs involves guest physical memory pages copied from a source host to a destination host but Clark does not teach or suggest a mapping between guest physical memory pages and locations in a virtual disk as claimed. Appeal Br. 13 (citing Clark

280 (§ 5.1)). Appellants also assert Scarfone's virtualized computing system implements a disk image as a file on a host that views a guest operating system (OS) as an entire disk drive, but argue that Scarfone does not teach or suggest a data structure that maps guest physical memory pages in a first set of guest physical memory pages of a virtual machine to locations in a virtual disk as claimed. *Id.* (citing Scarfone § 2.3.2).

ISSUE

Under § 103(a), has the Examiner erred in rejecting claim 1 by finding Clark and Scarfone collectively teach or suggest "accessing a data structure that provides a mapping of each guest physical memory page in a first set of guest physical memory pages of a virtual machine to a location in a virtual disk having the same contents as the guest physical memory page to determine the guest physical memory pages in the first set"?

ANALYSIS

We begin by noting the Examiner and Appellants extensively brief how the phrase "guest physical memory page" should be construed. *See* Appeal Br. 7–9; Ans. 3–20, 26; Reply Br. 2–4.[4] According to Appellants, the phrase "means a page in a physical memory of a virtual machine that is running in a host computer, where the physical memory of the virtual machine is not the host computer's physical memory but an emulated version of the host computer's physical memory." Appeal Br. 9. According

[4] Although Appellants' Reply Brief (consisting of four pages) is not paginated, we nonetheless cite specific pages of the Reply Brief in the order that they appear in the record.

to the Examiner, the phrase is "a page stored by a guest physical operating system in physical memory." Ans. 25. Regardless of how the phrase "guest physical memory page" is construed, we see no error in the Examiner's obviousness rejection.

The Examiner relies principally on Clark for teaching many of the recited elements of claim 1. Final Act. 9–10. Of particular note, the Examiner finds Clark teaches providing a mapping of each guest physical memory page. *See id.* (citing Clark 280 (§ 5.1 ¶ 3)). The Examiner finds Clark's mapping does not include a mapping of its memory pages to a location in a virtual disk, turning to Scarfone to show that mapping pages to virtual disk locations is known in the art. Final Act. 10. The Examiner proposes to include Scarfone's teaching with Clark, such that the combined system predictably yields mapping of guest physical memory pages to a location in a virtual disk as recited. *See* Final Act. 10 (citing Scarfone § 2.3.2 ¶¶ 1-2 and § 2.3.3 ¶ 1).

Appellants do not persuasively rebut the Examiner's reliance on Clark's mapping of a guest physical memory page and its associated functionality that, when combined with Scarfone, at least suggests mapping the guest physical memory page to a location in a virtual disk. First, Appellants do not dispute Clark teaches guest physical memory pages or a mapping that involves these pages. *See* Appeal Br. 13 (indicating Clark teaches page tables and a mapping between guest virtual memory locations and guest physical memory locations). Second, although Clark's copying of a guest physical memory page to a destination host does not involve mapping the guest physical memory page *to a location in a virtual disk* as Appellants contend (Appeal Br. 13), the Examiner's findings in this regard

are not based solely on Clark, but rather the combination of Clark and Scarfone. Final Act. 10. Third, although Scarfone's description of a virtual disk does not map a guest *physical memory* page to a virtual disk as Appellants contend (Appeal Br. 13), the Examiner's findings in this regard are not based solely on Scarfone, but rather the combination of Clark and Scarfone.

Thus, Appellants' arguments regarding Clark's and Scarfone's alleged individual shortcomings with respect to mapping a guest physical memory pages to a virtual disk (*id.*) are unavailing. Here, the rejection is not based solely on either Clark or Scarfone individually, but rather on the cited references' collective teachings. *See In re Merck & Co., Inc.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986); *In re Keller*, 642 F.2d 413, 426 (CCPA 1981). *Accord* Ans. 21 (finding "Appellant . . . has not argued that the combination of Clark and Scarfone fail[s] to teach page table operations of a guest operating system running on a virtual machine."). For the reasons discussed above, Appellants have not persuasively rebutted the Examiner's findings and conclusion regarding what the references collectively suggest to an ordinary artisan.

For the foregoing reasons, Appellants' arguments have not persuaded us of error in the rejection of independent claim 1 and claims 2, 4, and 6–9 which are not separately argued.

THE OBVIOUSNESS REJECTION OVER WALDSPURGER AND BERGER

The Examiner finds Waldspurger teaches many recited elements of independent claim 11, including a storage device that stores a virtual disk for

a virtual machine. Final Act. 21 (citing Waldspurger 3 (col. 1)). The Examiner also cites Waldspurger for teaching a mapping of a guest physical memory page to the virtual disk. *Id.* (citing Waldspurger 2 (§ 2)); Ans. 23. The Examiner further cites Berger in combination with Waldspurger to teach this feature and concludes the claim would have been obvious. Final Act. 21–22 (citing Berger § 15.1.2).

Appellants assert Waldspurger teaches a mapping between guest physical memory and machine memory but argues Waldspurger does not teach "the mapping of guest physical memory to locations on a disk." Appeal Br. 15 (citing Waldspurger 2 (§ 2)). Appellants further assert Berger's bit in a page table indicates whether a page's copy in physical memory matches a disk's copy but argues Berger's bit "provides no information regarding which 'physical memory page' maps to a particular location on disk." *Id.* (citing Berger § 15.1.2).

ISSUE

Under § 103(a), has the Examiner erred in rejecting claim 11 by finding Waldspurger and Berger collectively teach or suggest a computer system comprising "a data structure that provides a mapping of each guest physical memory page in a set of guest physical memory pages of a virtual machine to a location in a virtual disk having the same contents as the guest physical memory page"?

ANALYSIS

Based on the record before us, we are not persuaded of error. In the rejection, the Examiner finds Waldspurger teaches a virtual disk for the

virtual machine and mapping guest physical memory pages to a location in the virtual disk. Final Act. 21 (citing Waldspurger 3 (§ 3.2) and 2 (§ 2)). To be sure, the Examiner discusses Berger additionally teaching this feature. Final Act. 21. However, in the Examiner's Answer, the Examiner discusses only page 3 of Waldspurger. We therefore confine our discussion to Waldspurger.

Waldspurger discusses a ballooning technique that involves loading a balloon module into a guest OS. Waldspurger 3 (§ 3.2); Fig. 1. Waldspurger's server instructs the balloon module to "inflate" thereby causing the guest OS to page particular pages out to its own virtual disk. *Id.* This ballooning technique, then, at least suggests a mapping of a guest physical memory page to a location in a virtual disk.

Appellants' argument that Waldspurger's alleged shortcomings involving a mapping between the guest physical memory and locations on a disk (Appeal Br. 15; *see also generally* Reply Br.) do not squarely address this teaching. *See* Final Act. 21; *see also* Ans. 23. Therefore, the Examiner's reliance on Waldspurger's page 3, which discusses the ballooning technique, has at least a rational basis to support an obviousness rejection that Appellants have not persuasively rebutted.

Appellants' arguments regarding Berger's alleged shortcomings pertaining to a mapping between the guest physical memory and locations on a disk (*id.* at 15) are unpersuasive. As noted above, the Examiner relies on Waldspurger to teach this feature. *See* Ans. 23; *see also* Final Act. 21. These arguments are also not germane to Berger's teaching of executing the management process on guest physical memory pages and replacing contents as recited in claim 11. *See* Final Act. 21–23.

For the foregoing reasons, Appellants' arguments have not persuaded us of error in the rejection of independent claim 11 and claims 12–18 which are not separately argued.

THE OBVIOUSNESS REJECTION OVER CLARK

The Examiner finds Clark teaches every recited element of independent claim 20 including, among other things, providing a first mapping of a guest physical memory page to a corresponding disk block of a virtual disk. Final Act. 28 (citing Clark 277 (§ 4.1)); Ans. 24. According to the Examiner, "[a] page table maps virtual addresses are [sic] mapped to locations in the disk as is well known (and shown in the diagram on page 14 of Appellants' brief). This constitutes an indirect mapping between the 'guest physical memory pages' and a 'location in the virtual disk.[']" Ans. 24.

Appellants assert Clark's shadow page table provides a mapping between locations in guest virtual memory and locations in machine memory, but Clark does not teach a mapping of guest physical memory to locations on a virtual disk. Appeal Br. 16.

ISSUE

Under § 103(a), has the Examiner erred in rejecting claim 20 by finding Clark teaches or suggests "a first data structure that provides first mappings of a set of guest physical memory pages of a virtual machine to corresponding disk blocks of a virtual disk of the virtual machine that store the same contents as the set of guest physical memory pages"?

ANALYSIS

Based on the record before us, we do not sustain the Examiner's obviousness rejection of independent claim 20. First, the Examiner's findings in the obviousness rejection of claim 20 regarding Clark's alleged mapping of a set of guest physical memory pages to a virtual disk's disk blocks is inconsistent with those made in connection with the obviousness rejection of independent claim 1. *Compare* Final Act. 10 (finding Clark does not teach or suggest a mapping to a virtual disk), *with id.* at 28 (finding Clark teaches or suggests a mapping to a virtual disk).

Leaving this inconsistency aside, we find the Examiner's obviousness rejection of claim 20 problematic for other reasons. A key aspect of the Examiner's rejection is a finding that a page table mapping virtual addresses to locations in a disk is well-known. Ans. 24 (citing "the diagram on page 14 of Appellants' Appeal brief"). Presuming the Examiner is relying on this figure to support the rejection, we note the rejection (Final Act. 28–30) relies on Clark alone. Notably, "[w]here a reference is relied on to support a rejection, whether or not in a 'minor capacity,' there would appear to be no excuse for not positively including the reference in the statement of the rejection." *In re Hoch*, 428, F.2d 1341, 1342 n.3, 166 USPQ 406, 407 n.3 (CCPA 1970)).

Additionally, even when considering this diagram, the Examiner does not explain sufficiently how a well-known fact of "virtual addresses [] mapped to locations in disk" (Ans. 24) "constitutes an *indirect* mapping between the 'guest physical memory pages' and a 'location in the virtual disk.'" Ans. 24 (emphasis added). Absent from this explanation is adequate evidence or sufficient technical reasoning to support the Examiner's findings

and conclusion that an indirect mapping between a guest physical memory page and a location in virtual disk is taught or suggested by Clark. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007) (indicating that "there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness").

Lastly, turning to the Examiner's other findings, Clark discloses using shadow page tables to track dirtying statistics on pages used by a particular executing OS. Clark 277 (§ 4.1), *cited in* Final Act. 28. Clark's shadow page tables allow determining which pages are written to by a virtual machine. *Id.* Although Clark discloses a virtual machine, the virtual machine itself is not a virtual disk. Nor has the Examiner shown a virtual disk to which the pages used by the particular executing OS are mapped. *See* Final Act. 28. We thus agree with Appellants that Clark does not teach or suggest mapping a guest physical memory page to a location in a virtual disk as recited in claim 20.

Accordingly, Appellants have persuaded us of error in the rejection of claim 20.

THE REMAINING OBVIOUSNESS REJECTIONS

Appellants have not separately argued the remaining rejections. Appeal Br. 11–17. Accordingly, we sustain the rejections of dependent claims 3, 5, 10, and 19 for reasons similar to those previously discussed when addressing the claims from which they depend respectively.

DECISION

We affirm the Examiner's rejections of claims 1–19 under 35 U.S.C. § 103(a).

We reverse the Examiner's rejection of claim 20 under § 103(a).

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a). *See* 37 C.F.R. § 41.50(f).

AFFIRMED-IN-PART