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(54) **INFORMATION MANAGEMENT OF
VIRTUAL MACHINES HAVING MAPPED
STORAGE DEVICES**

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707/653, 661, 667, 674; 718/1, 104
See application file for complete search history.

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(56) **References Cited**

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U.S. PATENT DOCUMENTS

4,686,620 A 8/1987 Ng
4,995,035 A 2/1991 Cole et al.

(Continued)

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FOREIGN PATENT DOCUMENTS

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EP 0259912 A1 3/1988
EP 0405926 A2 1/1991

(Continued)

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OTHER PUBLICATIONS

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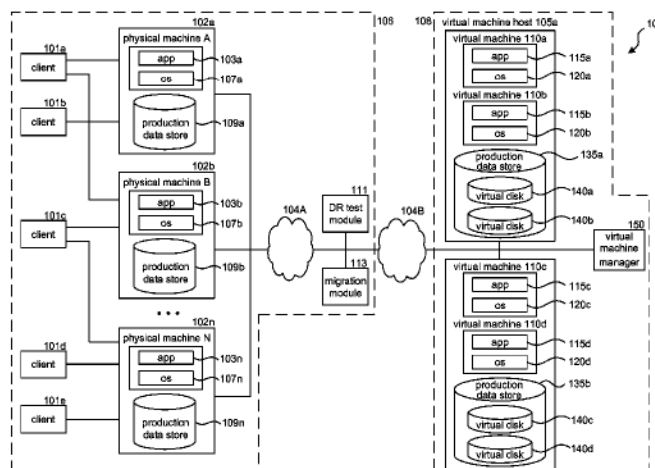
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(57)

ABSTRACT

Software, firmware, and systems are described herein that create and use a non-production copy of a virtual machine for reverting or restoring the virtual machine. The virtual machine is associated with an external storage device via a logical mapping. A snapshot is taken of a virtual disk associated with the virtual machine to create a snapshot copy of the virtual disk. A snapshot is taken of at least a portion of the mapped external storage device to create a snapshot copy of the mapped external storage device. The snapshot copy of the virtual disk is associated with the snapshot copy of the mapped external storage device. The snapshot copies can then be used to either revert or restore the virtual machine.

20 Claims, 12 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

5,005,122 A 4/1991 Griffin et al.
 5,093,912 A 3/1992 Dong et al.
 5,133,065 A 7/1992 Cheffetz et al.
 5,193,154 A 3/1993 Kitajima et al.
 5,212,772 A 5/1993 Masters
 5,226,157 A 7/1993 Nakano et al.
 5,239,647 A 8/1993 Anglin et al.
 5,241,668 A 8/1993 Eastridge et al.
 5,241,670 A 8/1993 Eastridge et al.
 5,276,860 A 1/1994 Fortier et al.
 5,276,867 A 1/1994 Kenley et al.
 5,287,500 A 2/1994 Stoppani, Jr.
 5,321,816 A 6/1994 Rogan et al.
 5,333,315 A 7/1994 Saether et al.
 5,347,653 A 9/1994 Flynn et al.
 5,410,700 A 4/1995 Fecteau et al.
 5,448,724 A 9/1995 Hayashi
 5,491,810 A 2/1996 Allen
 5,495,607 A 2/1996 Pisello et al.
 5,504,873 A 4/1996 Martin et al.
 5,544,345 A 8/1996 Carpenter et al.
 5,544,347 A 8/1996 Yanai et al.
 5,559,957 A 9/1996 Balk
 5,619,644 A 4/1997 Crockett et al.
 5,638,509 A 6/1997 Dunphy et al.
 5,673,381 A 9/1997 Huai et al.
 5,699,361 A 12/1997 Ding et al.
 5,729,743 A 3/1998 Squibb
 5,751,997 A 5/1998 Kullick et al.
 5,758,359 A 5/1998 Saxon
 5,761,677 A 6/1998 Senator et al.
 5,764,972 A 6/1998 Crouse et al.
 5,778,395 A 7/1998 Whiting et al.
 5,812,398 A 9/1998 Nielsen
 5,813,009 A 9/1998 Johnson et al.
 5,813,017 A 9/1998 Morris
 5,875,478 A 2/1999 Blumenau
 5,887,134 A 3/1999 Ebrahim
 5,901,327 A 5/1999 Ofek
 5,924,102 A 7/1999 Perks
 5,950,205 A 9/1999 Aviani, Jr.
 5,974,563 A 10/1999 Beeler, Jr.
 6,021,415 A 2/2000 Cannon et al.
 6,026,414 A 2/2000 Anglin
 6,052,735 A 4/2000 Ulrich et al.
 6,076,148 A 6/2000 Kedem
 6,094,416 A 7/2000 Ying
 6,131,095 A 10/2000 Low et al.
 6,131,190 A 10/2000 Sidwell
 6,148,412 A 11/2000 Cannon et al.
 6,154,787 A 11/2000 Urevig et al.
 6,161,111 A 12/2000 Mutalik et al.
 6,167,402 A 12/2000 Yeager
 6,212,512 B1 4/2001 Barney et al.
 6,260,069 B1 7/2001 Anglin
 6,269,431 B1 7/2001 Dunham
 6,275,953 B1 8/2001 Vahalia et al.
 6,301,592 B1 10/2001 Aoyama et al.
 6,324,581 B1 11/2001 Xu et al.
 6,328,766 B1 12/2001 Long
 6,330,570 B1 12/2001 Crighton
 6,330,642 B1 12/2001 Carteau
 6,343,324 B1 1/2002 Hubis et al.
 RE37,601 E 3/2002 Eastridge et al.
 6,356,801 B1 3/2002 Goodman et al.
 6,389,432 B1 5/2002 Pothapragada et al.
 6,397,242 B1* 5/2002 Devine et al. 718/1
 6,421,711 B1 7/2002 Blumenau et al.
 6,487,561 B1 11/2002 Ofek et al.
 6,519,679 B2 2/2003 Devireddy et al.
 6,538,669 B1 3/2003 Lagueux, Jr. et al.
 6,564,228 B1 5/2003 O'Connor
 6,581,076 B1 6/2003 Ching et al.

7,076,270 B2 7/2006 Jagers et al.
 7,219,162 B2 5/2007 Donker et al.
 7,246,207 B2 7/2007 Kottomtharayil et al.
 7,395,282 B1 7/2008 Crescenti et al.
 7,448,079 B2 11/2008 Tremain
 7,552,279 B1* 6/2009 Gandler 711/114
 7,631,351 B2 12/2009 Erofeev
 7,730,035 B2 6/2010 Berger et al.
 7,756,835 B2 7/2010 Pugh
 7,756,964 B2 7/2010 Madison, Jr. et al.
 7,793,307 B2* 9/2010 Gokhale et al. 719/324
 7,840,537 B2 11/2010 Gokhale et al.
 7,882,077 B2 2/2011 Gokhale et al.
 7,899,788 B2 3/2011 Chandhok et al.
 7,937,421 B2 5/2011 Mikesell et al.
 8,069,271 B2 11/2011 Brunet et al.
 8,140,786 B2 3/2012 Bunte et al.
 8,219,524 B2 7/2012 Gokhale
 8,307,177 B2 11/2012 Prahlad et al.
 8,578,126 B1* 11/2013 Gaonkar et al. 711/201
 2004/0030668 A1* 2/2004 Pawlowski et al. 707/1
 2004/0030822 A1* 2/2004 Rajan et al. 711/4
 2006/0224846 A1 10/2006 Amarendran et al.
 2007/0100792 A1* 5/2007 Lent et al. 707/1
 2007/0203938 A1 8/2007 Prahlad et al.
 2007/0234302 A1* 10/2007 Suzuki et al. 717/126
 2008/0189468 A1* 8/2008 Schmidt et al. 711/6
 2008/0244177 A1* 10/2008 Crescenti et al. 711/114
 2008/0313371 A1* 12/2008 Kedem et al. 710/68
 2009/0144416 A1 6/2009 Chatley et al.
 2009/0222496 A1* 9/2009 Liu et al. 707/204
 2009/0300023 A1* 12/2009 Vaghani 707/10
 2009/0319534 A1 12/2009 Gokhale
 2009/0327471 A1 12/2009 Astete et al.
 2009/0327477 A1* 12/2009 Madison et al. 709/224
 2010/0070725 A1* 3/2010 Prahlad et al. 711/162
 2010/0161919 A1* 6/2010 Dodgson et al. 711/161
 2010/0242096 A1 9/2010 Varadharajan et al.
 2010/0332454 A1 12/2010 Prahlad et al.
 2011/0087632 A1 4/2011 Subramanian et al.
 2011/0093471 A1 4/2011 Brockway et al.
 2011/0179414 A1* 7/2011 Goggin et al. 718/1
 2011/0219144 A1* 9/2011 Amit et al. 709/247
 2012/0084262 A1 4/2012 Dwarampudi et al.
 2012/0254364 A1 10/2012 Vijayan
 2013/0054533 A1* 2/2013 Hao et al. 707/649
 2013/0061014 A1 3/2013 Prahlad et al.

FOREIGN PATENT DOCUMENTS

EP 0467546 A2 1/1992
 EP 0774715 A1 5/1997
 EP 0809184 A1 11/1997
 EP 0899662 A1 3/1999
 EP 0981090 A1 2/2000
 WO WO-9513580 A1 5/1995
 WO WO-9912098 A1 3/1999

OTHER PUBLICATIONS

U.S. Appl. No. 13/789,871, filed Mar. 8, 2013, Kumarasamy et al.
 U.S. Appl. No. 13/790,028, filed Mar. 8, 2013, Kumarasamy et al.
 U.S. Appl. No. 13/926,332, filed Jun. 25, 2013, Dwarampudi et al.
 Armstead et al., "Implementation of a Campus-wide Distributed Mass Storage Service: The Dream vs. Reality," *IEEE*, Sep. 11-14, 1995, pp. 190-199.
 Arneson, "Mass Storage Archiving in Network Environments," Digest of Papers, Ninth IEEE Symposium on Mass Storage Systems, Oct. 31, 1988-Nov. 3, 1988, pp. 45-50, Monterey, CA.
 Brandon, J., "Virtualization Shakes Up Backup Strategy," <<http://www.computerworld.com>>, internet accessed on Mar. 6, 2008, 3 pages.
 Cabrera et al., "ADSM: A Multi-Platform, Scalable, Backup and Archive Mass Storage System," Digest of Papers, Compcon '95, Proceedings of the 40th IEEE Computer Society International Conference, May 5-9, 1995, pp. 100-105, Dallas, Texas.

(56)

References Cited**OTHER PUBLICATIONS**

Consolidated Backup (VCB) Certification Information Kit," 2007, 23 pages.

CommVault Systems, Inc., "CommVault Solutions—VMware," <<http://www.commvault.com/solutions/vmware/>>, internet accessed Mar. 24, 2008, 2 pages.

CommVault Systems, Inc., "Enhanced Protection and Manageability of Virtual Servers," Partner Solution Brief, 2008, 6 pages.

Davis, D., "3 VMware Consolidated Backup (VCB) Utilities You Should Know," Petri IT Knowledgebase, <<http://www.petri.co.il/vmware-consolidated-backup-utilities.htm>>, internet accessed on Jul. 14, 2008, 7 pages.

Davis, D., "Understanding VMware VMX Configuration Files," Petri IT Knowledgebase, <http://www.petri.co.il/virtual_vmware_vmx_configuration_files.htm>, internet accessed on Jun. 19, 2008, 6 pages.

Davis, D., "VMware Server & Workstation Disk Files Explained," Petri IT Knowledgebase, <http://www.petri.co.il/virtual_vmware_files_explained.htm>, internet accessed on Jun. 19, 2008, 5 pages.

Davis, D., "VMware Versions Compared," Petri IT Knowledgebase, <http://www.petri.co.il/virtual_vmware_versions_compared.htm>, internet accessed on Apr. 28, 2008, 6 pages.

Eitel, "Backup and Storage Management in Distributed Heterogeneous Environments," *IEEE*, Jun. 12-16, 1994, pp. 124-126.

International Preliminary Report on Patentability and Written Opinion for PCT/US2011/054374, dated Apr. 11, 2013, 6 pages.

International Search Report and Written Opinion for PCT/US2011/054374, dated May 2, 2012, 9 pages.

Jander, M., "Launching Storage-Area Net," *Data Communications*, US, McGraw Hill, NY, vol. 27, No. 4 (Mar. 21, 1998), pp. 64-72.

Jason Gait, "The Optical File Cabinet: A Random-Access File System for Write-Once Optical Disks," *IEEE Computer*, vol. 21, No. 6, pp. 11-22 (Jun. 1988).

Microsoft Corporation, "How NTFS Works," Windows Server TechCenter, updated Mar. 28, 2003, internet accessed Mar. 26, 2008, 26 pages.

Rosenblum et al., "The Design and Implementation of a Log-Structured File System," *Operating Systems Review SIGOPS*, vol. 25, No. 5, New York, US, pp. 1-15 (May 1991).

Sanbarrow.com, "Disktype-table," <<http://sanbarrow.com/vmdk/disktypes.html>>, internet accessed on Jul. 22, 2008, 4 pages.

Sanbarrow.com, "Files Used by a VM," <<http://sanbarrow.com/vmx/vmx-files-used-by-avm.html>>, internet accessed on Jul. 22, 2008, 2 pages.

Sanbarrow.com, "Monolithic Versus Split Disks," <<http://sanbarrow.com/vmdk/monolithicversussplit.html>>, internet accessed on Jul. 14, 2008, 2 pages.

VMware, Inc., "Open Virtual Machine Format," <<http://www.vmware.com/appliances/learn/ovf.html>>, internet accessed on May 6, 2008, 2 pages.

VMware, Inc., "OVF, Open Virtual Machine Format Specification, version 0.9," White Paper, <<http://www.vmware.com>>, 2007, 50 pages.

VMware, Inc., "The Open Virtual Machine Format Whitepaper for OVF Specification, version 0.9," White Paper, <<http://www.vmware.com>>, 2007, 16 pages.

VMware, Inc., "Understanding VMware Consolidated Backup," White Paper, <<http://www.vmware.com>>, 2007, 11 pages.

VMware, Inc., "Using VMware Infrastructure for Backup and Restore," Best Practices, <<http://www.vmware.com>>, 2006, 20 pages.

VMware, Inc., "Virtual Disk API Programming Guide," <<http://www.vmware.com>>, Revision Apr. 11, 2008, 2008, 44 pages.

VMware, Inc., "Virtual Disk Format 1.1," VMware Technical Note, <<http://www.vmware.com>>, Revision Nov. 13, 2007, Version 1.1, 2007, 18 pages.

VMware, Inc., "Virtual Machine Backup Guide, ESX Server 3.0.1 and VirtualCenter 2.0.1," <<http://www.vmware.com>>, updated Nov. 21, 2007, 74 pages.

VMware, Inc., "Virtual Machine Backup Guide, ESX Server 3.5, ESX Server 3i version 3.5, VirtualCenter 2.5," <<http://www.vmware.com>>, updated Feb. 21, 2008, 78 pages.

VMware, Inc., "Virtualized iSCSI Sans: Flexible, Scalable Enterprise Storage for Virtual Infrastructures," White Paper, <<http://www.vmware.com>>, Mar. 2008, 13 pages.

VMware, Inc., "VMware Consolidated Backup, Improvements in Version 3.5," Information Guide, <<http://www.vmware.com>>, 2007, 11 pages.

VMware, Inc., "VMware Consolidated Backup," Product Datasheet, <<http://www.vmware.com>>, 2007, 2 pages.

VMware, Inc., "VMware ESX 3.5," Product Datasheet, <<http://www.vmware.com>>, 2008, 4 pages.

VMware, Inc., "VMware GSX Server 3.2, Disk Types: Virtual and Physical," <http://www.vmware.com/support/gsx3/doc/disks_types_gsx.html>, internet accessed on Mar. 25, 2008, 2 pages.

VMware, Inc., "VMware OVF Tool," Technical Note, <<http://www.vmware.com>>, 2007, 4 pages.

VMware, Inc., "VMware Workstation 5.0, Snapshots in a Linear Process," <http://www.vmware.com/support/ws5/doc/ws_preserve_sshot_linear.html>, internet accessed on Mar. 25, 2008, 1 page.

VMware, Inc., "VMware Workstation 5.0, Snapshots in a Process Tree," <http://www.vmware.com/support/ws5/doc/ws_preserve_sshot_tree.html>, internet accessed on Mar. 25, 2008, 1 page.

VMware, Inc., "VMware Workstation 5.5, What Files Make Up a Virtual Machine?" <http://www.vmware.com/support/ws55/doc/ws_learning_files_in_a_vm.html>, internet accessed on Mar. 25, 2008, 2 pages.

Wikipedia, "Cluster (file system)," <http://en.wikipedia.org/wiki/Cluster_%28file_system%29>, internet accessed Jul. 25, 2008, 1 page.

Wikipedia, "Cylinder-head-sector," <<http://en.wikipedia.org/wiki/Cylinder-head-sector>>, internet accessed Jul. 22, 2008, 6 pages.

Wikipedia, "File Allocation Table," <http://en.wikipedia.org/wiki/File_Allocation_Table>, internet accessed on Jul. 25, 2008, 19 pages.

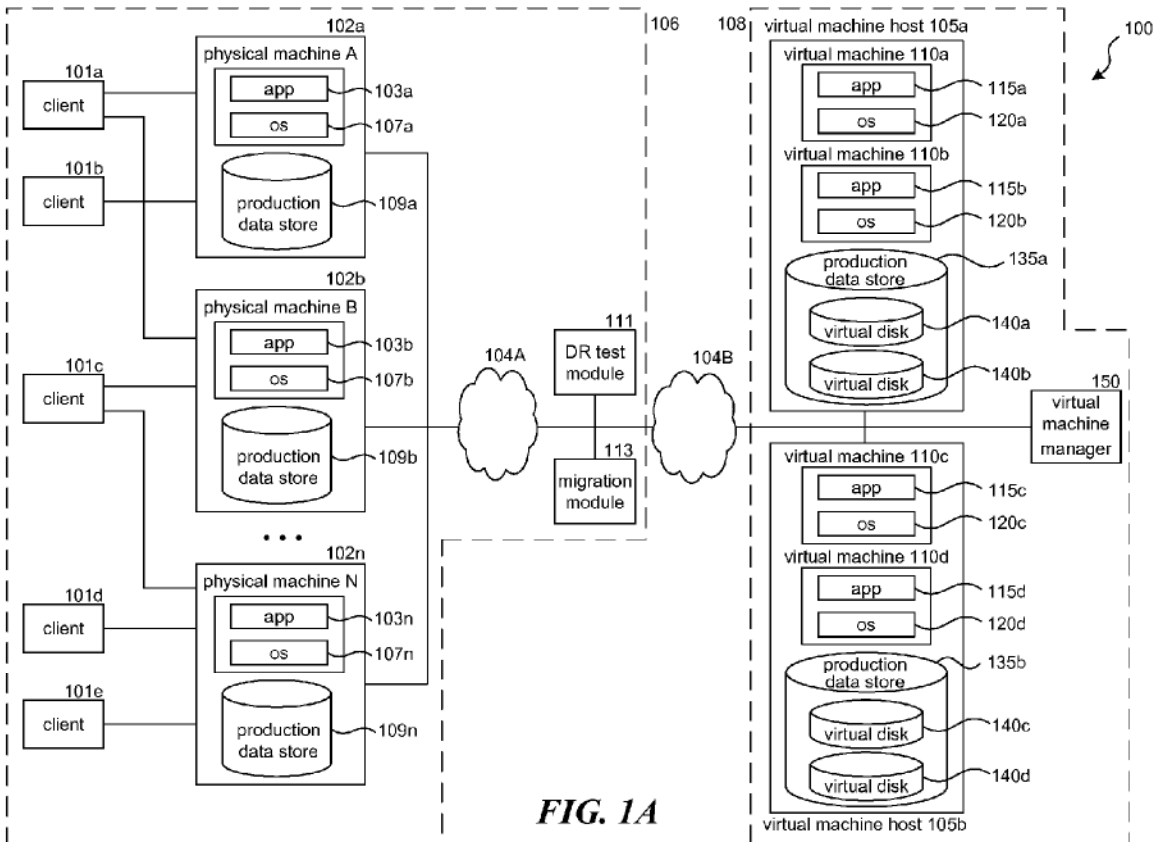
Wikipedia, "Logical Disk Manager," <http://en.wikipedia.org/wiki/Logical_Disk_Manager>, internet accessed Mar. 26, 2008, 3 pages.

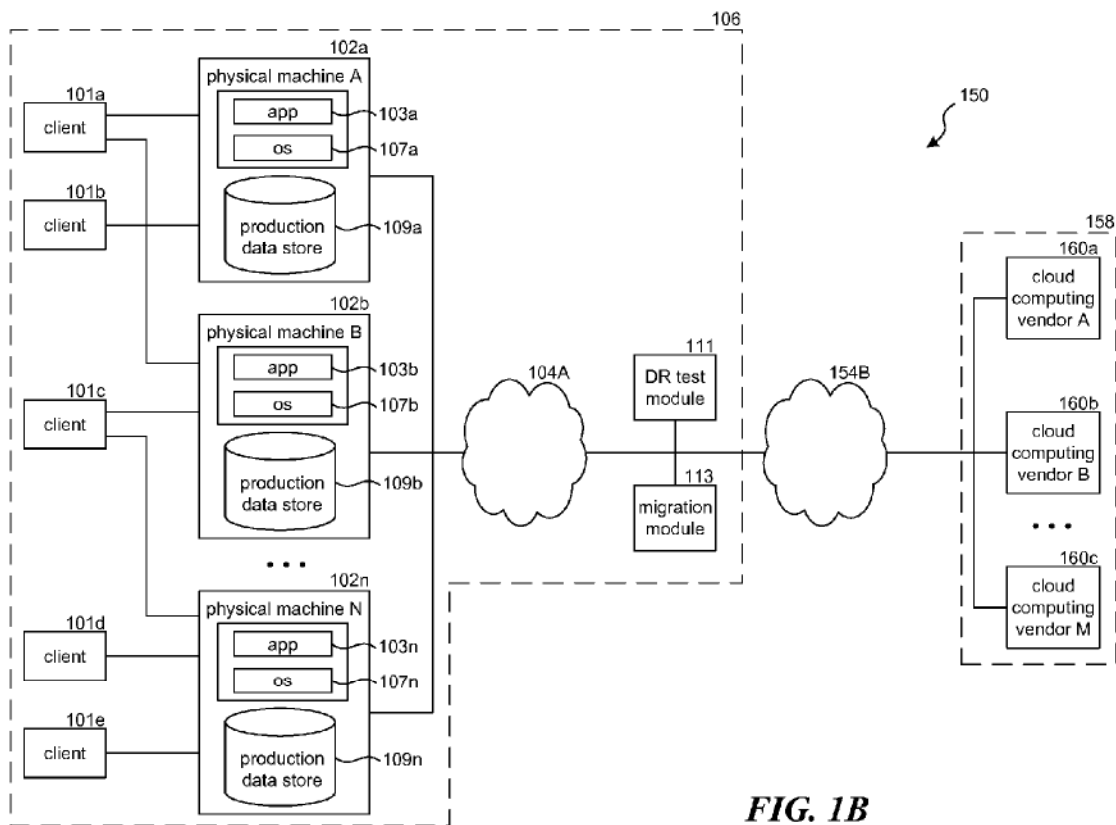
Wikipedia, "Logical vol. Management," <http://en.wikipedia.org/wiki/Logical_volume_management>, internet accessed on Mar. 26, 2008, 5 pages.

Wikipedia, "Storage Area Network," <http://en.wikipedia.org/wiki/Storage_area_network>, internet accessed on Oct. 24, 2008, 5 pages.

Wikipedia, "Virtualization," <<http://en.wikipedia.org/wiki/Virtualization>>, internet accessed Mar. 18, 2008, 7 pages.

* cited by examiner





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