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Version of Microsoft Office released in 2013 Microsoft Office 2013 applications from top left to bottom right: Word, Excel, PowerPoint and Outlook which collectively make up the Home & Business edition. Developer(s) Microsoft Office 2013; 12 years ago (2013-01-29)[1] Stable release Service Pack 1
(15.0.5603.1000) / November 7, 2023; 18 months ago (2023-11-07)[2] Operating systemWindows 7 or laterWindows Server 2008 R2 or later[3]PlatformIA-32, x64, ARMPredecessorMicrosoft Office 2010 (2010)SuccessorMicrosoft Office 2016 (2015)Available in 40 languages[4]List of languagesEnglish, Arabic, Bulgarian, Chinese (Simplified), Chinese,
Croatian, Czech, Danish, Dutch, Estonian, French, German, Greek, Hebrew, Hindi, Hungarian, Indonesian, Italian, Japanese, Kazakh, Korean, Latvian, Lithuanian, Malay, Norwegian (Bokmål), Polish, Portuguese (Brazil), Port
VietnameseTypeOffice suiteLicenseTrialware[5]OneNote: Freemium (since 2014)Websiteproducts.office.com/microsoft Office 2013 (codenamed Office 2013 (codenamed Office 2013) Microsoft Office 2013 includes
extended file format support, user interface updates and support for touch among its new features and is suitable for IA-32 and x64 systems.[7] Office 2013 is compatible with Windows Server 2008 R2 through Windows Server 2019.[8][9][10][11][8] A version of Office 2013 comes included on RT devices.[12][3]
It is the last version of Microsoft Office to support Windows 7 RTM and Windows Server 2008 R2 RTM. Development on this version of Microsoft Office was started in 2010 and ended on October 11, 2012, when Microsoft Office 2013 was released to manufacturing.[13] Microsoft Office 2013 to general availability on January 29, 2013.[1] This
version includes new features such as integration support for Office Open XML (OOXML), OpenDocument (ODF) and Portable Document Format (PDF) and support for multi-touch interfaces. Microsoft Office 2013 comes in twelve different
editions, including three editions for retail outlets, two editions for volume licensing channel, five subscription-based editions available through Microsoft Office RT edition made for tablets and mobile devices. Office Web Apps are available free of charge on the web
although enterprises may obtain on-premises installations for a price. Microsoft Visio, Mic
release (RTM) ended on April 14, 2015, and Service Pack 1 is required for receiving updates and support. Support for Office 2013 ended on April 11, 2023.[15] On June 9, 2018, Microsoft announced that its forums would no longer include Office 2013 or other products in extended support among its products for discussions involving support.[16] On
August 27, 2021, Microsoft announced that Microsoft Outlook 2013 SP1 with all subsequent updates will be required to connect to Microsoft 365 Exchange servers by November 1, 2021; Outlook 2013 without SP1 will no longer be supported.[17][18][additional citation(s) needed][inconsistent] Office 2013 removed support for processors without PAE,
SSE2 and NX and is also the final version of Microsoft Office to receive a Service Pack from Microsoft. Despite the end of support
for Office 2013 in April, Microsoft is still rolling out monthly security patches for the Office 15, build 3612.1010, to a
selected group of testers bound by non-disclosure agreements.[21] On July 16, 2012, Microsoft held a press conference to showcase Office 2013 Consumer Preview is a free, fully functional version but will expire 60 days after the final product's release.[23][24] An update was issued for the
Office 2013 Customer Preview suite on October 5.[25] Office 2013 was released to manufacturing on October 11, 2012.[13] It was made available to TechNet and MSDN subscribers on October 24, 2012.[26] On November 15, 2012 for one of the control of 
were made available to the public over the Internet.[5][27] Microsoft has released Office 2013 for general availability on January 29, 2013.[1] Microsoft released the service pack 1 update on February 25, 2014.[28] Office 2013 introduces Click-To-Run 2.0 installation technology for all editions based on Microsoft App-V Version 5.[29] Previously, only
certain editions of Office 2010 were available with Click-To-Run 1.0 installer technology, which was based on App-V 4.x, where a separate Q drive was created and installed files of Office were isolated from the rest of the system, causing many Office add-ins to not be compatible.[30] With the newer Click-To-Run technology, Office 2013 installs files
just like Windows Installer (MSI) to the Program Files directory. Retail versions of Office 2013 use the Click-to-Run installer. Volume-licensed versions like Professional Plus are available in both retail (C2R) and volume (MSI) channels. Office 2013 is more cloud-based than previous versions;
a domain login, Office 365 account, or Microsoft account can now be used to sync Office application settings (including recent documents) between devices, and users can also save documents directly to their OneDrive account.[32] Microsoft Office 2013 includes updated support for ISO/IEC 29500, the International Standard version of Office Open
XML (OOXML) file format: in particular it supports saving in the "Strict" profile of ISO/IEC 26300:2006, Open Document Format, [33] which Office 2013 can read and write. [34] Additionally, Office 2013 provides full read, write, and edit support for ISO 32000 (PDF).
New features include a new read mode in Microsoft Word, a presentation mode in Microsoft Word and PowerPoint also have bookmark-like
features which sync the position of the document between different computers. The Office Web Apps suite was also updated for Office 2013 include: PDF Import feature in Microsoft Word Improved text wrapping and improved Track Changes feature in
Microsoft Word Flash Fill in Microsoft Excel Office Remote/Microsoft PowerPoint Remote app and Office add-in to control presentations from a Windows Phone or Android phone. Automatic slide resizing/refit in Microsoft Visio Flatter look of the Ribbon interface and subtle
animations when typing or selecting (Word and Excel) Band in application color at bottom of each screen A new visualization for scheduled tasks in Microsoft Outlook Remodeled start screen[37] New graphical options in Word[38] Objects such as images can be freely moved; they snap to boundaries such as paragraph edges, document margin and or
column boundaries Supports embedding of Online picture support with content from Office.com, Bing.com and Flickr (by default, only images in public domain) to in replacement to the cliparts gallery from previews office versions. Ability to return to the last viewed or edited location in Word and PowerPoint New slide designs, animations and
transitions in PowerPoint 2013 Support for Outlook.com and Hotmail.com in Outlook Support for integration with Skype, Yammer and SkyDrive[39] IMAP special folders support for Outlook.com and Hotmail.com in Outlook Support for integration with Office 2013, proofing tools are separately and freely downloadable without being bundled in Multilingual User Interface (MUI)/Multilanguage packs,
Language Interface Packs (LIPs) or Single Language Packs (SLP).[41] Excel 2013 supports new limit models, as follows:[42] Quantifiable limits in objects Object Upper limit Characters in a table or column name 100 characters Number of tables in a model 2,147,483,647 bytes (2 GB minus 1 byte) Number of tables in a table or columns and calculated columns in a table or column name 100 characters.
2,147,483,647 bytes (2 GB minus 1 byte) Memory limit, checked when saving a workbook 4,294,967,296 bytes (4 GB) Concurrent requests per workbook 6 Number of connections 5 Num
Details Reserved characters that cannot be used in a Name1.,; '`: /\*|?" & % $! + = () [] {} <> Removed from Microsoft Clip Organizer Microsoft Cl
Office Picture Manager Office 2007 and Office 2010 chart styles Ability to insert a 3D cone, pyramid, or cylinder chart (It is still possible to insert a 3D rectangle chart and change the shape after insertion.[44]) Only basic version of help files available while offline. There is no longer an option to install local help files during installation.[45] Features
removed from Microsoft Word Custom XML markup has been removed for legal reasons Older WordArt objects are now converted to new WordArt objects Word 2013 no longer uses ClearType[46] Features removed from Microsoft Excel Simultaneous open files via Multiple Document Interface (MDI), along with requisite changes to VBA code to no
longer support MDI; Excel is now Single Document Interface (SDI) only[47] Features removed from Microsoft Outlook Download Headers Only mode for IMAP[48] Outlook Exchange Classic offline Microsoft
 Search through Windows Shell[44] Features removed from Microsoft PowerPoint Support for Visio Drawing Unlike past versions of Office, retail copies of Office, retail copies of Office 2013 on DVD are only offered in select regions, such as those Microsoft classifies as emerging markets, as well as Australia, at the discretion of retailers. In all other regions, retail copies of
Office 2013 and Office 365 subscriptions only contain a product key, and direct users to the Office website to redeem their license agreement for retail editions of Microsoft Office in two
 significant ways.[52] The first of these was that the software could no longer be transferred to another computer. In previous versions of Office, this restriction applied only to OEM editions; retail Office were also said
to be permanently locked to that PC's hardware, preventing it from being transferred to any other computing device. Should the buyer have wished to use Office 2013 on a different computing device that the original license was downloaded to (e.g. hardware became inoperable due to malfunction)
 then a completely new, full-priced copy of Office 2013 would have to have been purchased to replace the prior one. [52] Microsoft stated that this change was related to the software piracy that has been rampant for years, worldwide. [53] However, many commentators saw this change as an effort to forcibly move its customers towards the
 subscription-based business model used by the Office 365 service. [54] [55] [56] The legality of this move, particularly in Europe, has been questioned. [57] However, on March 6, 2013, Microsoft announced that equivalent transfer rights to those in the Office 2010 retail license agreements are applicable to retail Office 2013 copies effective
immediately. Transfer of license from one computer to another owned by the same user is now allowed every 90 days, except in the case of hardware failure, in which the license may be moved sooner. The first user of the product is now allowed every 90 days, except in the case of hardware failure, in which the license may be moved sooner. The first user of the product is now allowed every 90 days, except in the case of hardware failure, in which the license may be moved sooner.
on. Lineup of Microsoft Office 2013 icons, from left to right: Word, Excel, PowerPoint, Outlook, Access, OneNote, Publisher, Lync and InfoPath As with previous versions of Microsoft Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions, Office 2013 icons, from left to right: Word, Excel, PowerPoint and InfoPath As with previous versions versions and InfoPath As with 
and OneNote and are licensed for use on one computer. Five traditional editions of Office 2013 were released: Home & Student: This retail suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook.[60]
Standard: This suite, only available through volume licensing channels, includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications Word, Excel, PowerPoint, and OneNote plus Outlook, Publisher and Access.[60] Professional Plus: This suite includes the core applications which is a professional Plus Outlook P
Microsoft Office 365 The Office 365 subscription services, which were previously aimed towards business and enterprise users, were expanded for Office 2013 to include new plans aimed at home use. The subscriptions allow use of the Office 2013 to include new plans aimed at home use.
Office 365, some of which also include value-added services, such as 20 GB of OneDrive storage (later increased to 1 TB) and 60 Skype minutes per month on the new Home Premium plan. [62] These new subscription offerings were positioned as a new option for consumers wanting a cost-effective way to purchase and use Office on multiple
computers in their household.[63] A special version of Office 2013, initially known as Office 2013 Home & Student RT, is shipped with all Windows RT devices. It initially consisted of Word, Excel, PowerPoint and OneNote. In Windows RT devices. It initially consisted of Word, Excel, PowerPoint and OneNote. In Windows RT devices. It initially known as Office 2013 RT and Outlook was added. The edition, whilst visually indistinguishable and oneNote.
from normal versions of Office 2013, contains special optimizations for ARM-based devices, such as changes to reduce battery usage (including, for example, freezing the animation of the blinking cursor for text editing during periods of inactivity), enabling touch mode by default to improve usability on tablets, and using the graphics portion of a
device's SoC for hardware acceleration.[64][65][66] Windows RT devices on launch were shipped with a "preview" version of Office Home & Student 2013 RT. The release date for the final version varied depending on the user's language, and was distributed through Windows Update when released.[66] On June 5, 2013, Microsoft announced that
 Windows RT 8.1 would add Outlook to the suite in response to public demand. [67] Office RT modifies or excludes other various features for compatibility reasons or resource reduction. To save disk space; templates, clip art, and language packs are downloaded online rather than stored locally. Other excluded features include the removal of suppor
for third-party code such as macros/VBA/ActiveX controls, the removal of support for older media formats and narration in PowerPoint, editing of equations generated with the legacy Equation Editor, data models in Excel (PivotCharts, PivotTables, and QueryTables are unaffected), searching embedded media files in OneNote, along with data loss
prevention, Group Policy support, and creating e-mails with information rights management in Outlook.[67][68] As the version of Office RT included on Windows RT devices is based on the Home & Student version, it cannot be used for "commercial, nonprofit, or revenue-generating activities" unless the organization has a volume license for Office
2013 already, or the user has an Office 365 subscription with commercial use rights. [69] Alongside Office RT, free versions of OneNote app, originally known as OneNote and the Lync client were made available as Windows Store apps. [70] The OneNote app, originally known as OneNote app, originally known as OneNote app.
use on tablets.[71] The OneNote app has since received several major updates, including camera integration, printing abilities, and multiple inking options. Universal Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information: Microsoft Word, Excel, and PowerPoint apps were released in 2015.[72][needs update] Further information apps were released in 2015.[72][needs 
the Office Mobile suite, consisting of mobile versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 7 versions, the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to their Windows Phone 8 versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new versions of Word, Excel, PowerPoint, and OneNote. In comparison to the new version to the new 
OneNote app with additional features (such as voice notes and integration with the new "Rooms" functionality of the OS), and improved document editing and viewing functionality. [74] In June 2013, Microsoft released a version of Office Mobile for iPhone; it is similar to the Windows Phone version, but originally requires an Office 365 subscription to
 use.[75] A version for Android smartphones was released in July 2013; it, too, originally needed Office 365 for use.[76] Apps for iPad and Android tablet computers were released in March 2014 and January 2015, respectively.[77][78] These, along with their smartphone equivalents, have been made free for personal use, though certain premium
features have been paywalled and require Office 365, which includes licensing of the apps for business use. Windows 10 Mobile that was released in December 2015 included new Office 365, which includes licensing of the apps for business use. Windows 10 Mobile that was released in December 2015 included new Office 365, which includes licensing of the apps for business use. Windows 10 Mobile that was released in December 2015 included new Office 365, which includes licensing of the apps for business use.
anindividual product Traditional editions[60][61][81] Office 365 subscriptions[60][82] Office RT Home & Student Home & Business Premium ProPlus Enterprise Availability Varies Windows RT Retail, OEM Retail, OEM Volume licensing Retail, OEM Retail, OEM
Volume licensing Software plus services Softw
of Office. 2 Commercial use of Office RT is allowed through volume licensing or business subscriptions to Office 365 Small Business Premium.[88][89] However, it's currently unavailable. 4 InfoPath was initially part of Office 365 Small Business Premium.[80] Through volume licensing or business subscriptions are also available.
is/was available with MSDN subscription or via Microsoft Office 2013 application has the following requirements. [91] Each Microsoft Office 2013 application application or via Microsoft Office 2013 application has the following requirements.
drive 3.0 GB free disk space Operating system Windows 7, Windows Server 2008 R2 or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these, graphics hardware acceleration requires a screen resolution of 1024×576 pixels or later In addition to these or later In addition to these of the required representation requires a screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition to the screen resolution of 1024×576 pixels or later In addition of 1024×576 pixe
hardware, however, Office 2013 applications can still run without graphics acceleration.)[92] List of office suites ^ a b c Page, Carly (January 28, 2013). "Microsoft says Office 2013 will arrive on 29 January". The Inquirer. Incisive Media. Archived from the original on January 31, 2013. Retrieved January 29, 2013. ^ "Update history for Office 2013".
 learn.microsoft.com. Archived from the original on July 18, 2023. Retrieved September 14, 2023. a b Ben-Zur, Liat; President, Corporate Vice; Life, Modern; Search; Devices (October 1, 2021). "It's easier to create together with Microsoft 365 and Office 2021". Microsoft 365 Blog. Archived from the original on October 6, 2021. Retrieved October 6,
 2021. ^ "Language identifiers and OptionState Id values in Office 2010". Microsoft. May 12, 2010. Archived from the original on March 7, 2008. Retrieved August 16, 2014, at the Wayback Machine, retrieved November 19, 2012 ^
 "Exclusive: A sneak peek at Office Web Apps Preview, coming with Office 2013 (and a new logo!)". Archived from the original on October 22, 2012. Retrieved August 27
2012. ^ a b McDougall, Patrick (July 18, 2012). "Office 2013 Won't Run On Windows XP, Vista". InformationWeek. UBM plc. Archived from the original on April 25, 2016. Archived from the original on January 19, 2013. Retrieved April 22, 2016. ^ Whitney, Lance
(July 19, 2012). "XP and Vista users, no Office 2013 for you". CNET. CBS Interactive. Archived from the original on April 14, 2016. Retrieved April 22, 2016. Archived from the original on May 3, 2016. Retrieved April 22, 2016. Archived from the original on May 3, 2016. Retrieved April 22, 2016.
 "Building Windows for the ARM processor architecture". Microsoft. February 9, 2012. Archived from the original on November 26, 2012. Retrieved June 28, 2012. ^ a b Koenigsbauer, Kirk (October 11, 2012). "Office Reaches RTM!". Office Reaches RTM!".
 Service Pack 1 (SP1) updates for Microsoft Office 2013 and related desktop products". Microsoft. February 25, 2014. Archived from the original on February 25, 2015. Retrieved February 25, 2014. ^ "End of support for Office 2013". support from the original on February 25, 2015. Retrieved April 11, 2023. Archived from the original on February 25, 2014. Archived from the original on April 11, 2023. Archived from the original on April 21, 2023. Archived from the original original on April 21, 2023. Archived from the original orig
 Woody (June 11, 2018). "Microsoft axes support on Answers Forum for Win 7, 8.1, Office 2010, 2013, many Surfaces". Computerworld. International Data Group. Archived from the original on November 9, 2020. Retrieved December 11, 2018. ^ "New minimum Outlook for Windows version requirements for Microsoft 365". Microsoft. August 27, 2021.
Archived from the original on September 14, 2021. Retrieved September 14, 2021. A Ben-Zur, Liat; President, Corporate Vice; Life, Modern; Search; Devices (October 1, 2021). "It's easier to create together with Microsoft 365 and Office 2021". Microsoft 365 Blog. Archived from the original on October 6, 2021. Retrieved October 6, 2021. A "Update of the original on October 1, 2021). "It's easier to create together with Microsoft 365 Blog. Archived from the original on October 6, 2021. The original orig
 history for Office 2013". Microsoft. August 31, 2023. Archived from the original on September 7, 2023. Archived from the original on November 7, 2023. Archived from the original on November 7, 2023. Archived from the original on September 16, 2023. Archived from the original on November 7, 2023. Archived from the original on September 16, 2023. Archived from the original on November 7, 2023. Archived from the original on September 16, 2023. Archived from the original on November 7, 2023. Archived from the original on November 8, 2023. Archived from the original on November 8, 2023. Archived from the original on November 8, 2023. Archived from the original origi
Preview: Tablet Readiness Questioned". PC World. January 30, 2012. Archived from the original on August 20, 2012. Retrieved June 7, 2013. Archived from the original on June 6, 2013. Retrieved June 7, 2013. Archived from the original on August 20, 2012. Retrieved August 20, 2012. Retrieved From the original on August 20, 2012. Archived from the original origi
release date 'today'". Computerworld.com. July 16, 2012. Archived from the original on October 1, 2012. Archived from the original on March 6, 2013. Retrieved February 24, 2013. ^ "Office 2013 Update Available for build 15.0.4128.1025"
2013 60-day trial now available for download". WinBeta. November 15, 2012. Archived from the original on November 18, 2012. Archived from the original on February 26, 2014. Retrieved February 25, 2014. Retrieved February 25, 2014. This is a contract of the contract of t
 "Office 2013 Preview App-V packages available (App-V 5.0 Beta)". Archived from the original on September 23, 2019. Retrieved September 23, 2019. ^ "Office installed with Click-to-Run and Windows Installer on same computer
isn't supported". Archived from the original on September 23, 2019. Retrieved September 23, 2019. A "Office 2013 Tip: Personalize the Office Applications". Paul Thurrott's Supersite for Windows. Archived from the original on April 5, 2013. A b "New file format options in the new Office". Office Next. August 13, 2012.
Archived from the original on September 18, 2012. Retrieved June 7, 2013. ^ "Microsoft Office 15 to support ODF 1.2". Archived from the original on September 2, 2011. Retrieved August 29, 2011. ^ "Office 2013 Web
 Apps: A step forward, but still dependent on the desktop". Ars Technica. July 18, 2012. Archived from the original on October 25, 2020. Retrieved October 1, 2020. ^ "What's new in Word 2013". Microsoft. Archived from the original on October 18, 2020. Archived from the original on October 19, 2020. Archived from the october 19, 2020. Archive
the original on February 11, 2013. Retrieved February 11, 2013. Retrieved February 18, 2013. ^ Mullins, Robert J. (July 16, 2012). "The New IMAP in Outlook 2013". Outlook Blog
Microsoft. Archived from the original on January 19, 2013. Retrieved July 29, 2013. ^ "Microsoft Office Proofing Tools 2013". Archived from the original on May 3, 2018. Retrieved July 29, 2013. ^ "Define and use
names in formulas". Office.com. Microsoft. Archived from the original on July 29, 2013. Retrieved July 29, 2013. A c d e Changes in Office 2013". Microsoft. Archived from the original on April 22, 2018. Retrieved May 8, 2013.
 "DevBlogs". Archived from the original on December 30, 2014. Retrieved August 25, 2014. "Programming for the Single Document Interface in Excel". March 30, 2022. Archived from the original on October 7, 2023. Retrieved June 17, 2018. Outlook Team (October 18, 2012). "The New IMAP in Outlook 2013". Outlook Blog. Archived from the
original on November 25, 2012. Retrieved November 2, 2012. A Thomas, Raul. "Outlook 2013: Unable to connect to an Exchange 2003 mailbox". Rahul Thomas Blogs, MSDN Blogs. Archived from the original on February 1, 2013. A "Office 2013 available now: Microsoft ditches DVDs in push for cloud subscriptions". The
 Verge. January 29, 2013. Archived from the original on March 9, 2013. Retrieved March 3, 2013. ^ James, Daniel (March 7, 2013). "Microsoft clarification: Office 2013 is available on DVD, if stores choose to stock it". BIT. Haymarket Media Group. Archived from the original on May 13, 2013. Retrieved June 7, 2013. ^ a b c d Thurrott, Paul (February
14, 2013). "Office 2013 Gotcha: Standalone Products are for One PC Only". Paul Thurrott's SuperSite for Windows. Penton Media. Archived from the original on February 17, 2013. Retrieved February 18, 2013.
March 12, 2013. ^ Bright, Peter (February 17, 2013). "Why Microsoft's new Office 2013 license may send users to Google Docs". Ars Technica. Archived from the original on May 27, 2013. ^ "Microsoft's new Office 2013 license may send users to Google Docs". Ars Technica. Archived from the original on May 27, 2013. ^ "Microsoft's new Office 2013 license may send users to Google Docs". Ars Technica. Archived from the original on May 27, 2013. ^ "Microsoft's new Office 2013 license may send users to Google Docs". Ars Technica. Archived from the original on May 27, 2013. ^ "Microsoft's new Office 2013 license may send users to Google Docs". Ars Technica. Archived from the original on May 27, 2013. ^ "Microsoft's new Office 2013 license may send users to Google Docs".
 February 18, 2013. Retrieved February 17, 2013. ^ "Microsoft Office 2013 lockdown aims to boost cloud services - Techworld.com". News.techworld.com. Archived from the original on June 27, 2013. ^ "Microsoft Office 2013 lockdown aims to boost cloud services - Techworld.com". News.techworld.com. Archived from the original on February 25.
2013. Retrieved February 25, 2013. ^ "Office News - Office 2013 now transferable". Blogs.office.com. March 6, 2013. Archived from the original on May 27, 2013. ^ "Microsoft retreats from Office 2013 restrictive licensing". Computerworld. March 6, 2013. Archived from the original on May 27, 2013. ^ "Microsoft retreats from Office 2013 restrictive licensing".
2013. ^ a b c d e Paul Thurrott (September 17, 2012). "Office 2013: Pricing and Packaging | Office content from Paul Thurrott's SuperSite for Windows". Winsupersite.com. Archived from the original on September 20, 2012. Retrieved November 21, 2012. ^ a b c "Compare suites available through volume licensing". Microsoft Office website.
Microsoft. Archived from the original on January 26, 2013. Retrieved January 29, 2013. Archived from the original on March
12, 2013. Retrieved March 15, 2013. ^ "Microsoft to deliver final version of Office 2013 RT starting in early November". ZDNet. September 14, 2012. Archived from the original on October 5, 2012. Retrieved October 5, 2012. Archived from the original on October 5, 2012. Retrieved October 5, 2012. Archived from the original on October 5, 2012. Retrieved October 5, 2012. Archived from the original on October 5, 2012. Archived from the original on October 5, 2012. Retrieved October 5, 2012. Archived from the original on October 5, 2012. Archived from the original original on October 5, 2012. Archived from the original o
October 5, 2012. ^ a b "Microsoft Details Office 2013 RT Availability and Features". Tablet PC Review. September 14, 2012. Archived from the original on October 23, 2012. Archived from the original on February 7, 2014. Retrieved June 5, 2013. ^ "Windows RT tablets". CNET. Archived from the original on February 7, 2014. Retrieved June 5, 2013. ^ "Windows RT tablets".
 won't get full Office 2013". PC Pro. August 8, 2012. Archived from the original on November 4, 2012. Archived from the original on November 28, 2014. Retrieved October 27, 2012. ^ "Microsoft's Lync and OneNote apps for
Windows 8, Windows RT now in Windows Store". ZDNet. CBS Interactive. Archived from the original on February 28, 2013. Retrieved March 14, 2013. ^ "Microsoft's touch-friendly Office apps now available to download for
 Windows 10". PC World. IDG. Archived from the original on February 6, 2015. Retrieved February 6, 2015. "Windows Phone 8: A tour of the business features". ZDNet. Archived from the original on April 3, 2013. Retrieved March 22, 2013. "Introducing the new Office on Windows Phone 8". Office Next. Microsoft. Archived from the original on April 3, 2013. The original on April 3, 2013. The original on April 3, 2015. The original original on April 3, 2015. The original origi
March 30, 2013. Retrieved March 22, 2013. "Office Mobile for iPhone Review". Paul Thurrott's Supersite for Windows. Archived from the original on February 11, 2014. Retrieved August 9, 2013. "Microsoft releases Office Mobile for Office 365 Android app". GSMArena. Archived from the original on February 11, 2014. Retrieved August 9, 2013. "Microsoft releases Office Mobile for Office 365 Android app".
 Emil Protalinski (March 27, 2014). "Office for iPhone and Android phones is now completely free, Android tablet version coming 'in the future'". The Next Web. Archived from the original on April 22, 2018. Retrieved June 18, 2018. Achived from the original on April 22, 2018. Retrieved June 18, 2018. Achived from the original on April 22, 2018. Retrieved June 18, 2018. Achived from the original on April 22, 2018. Retrieved June 18, 2018. Achived from the original on April 22, 2018. Retrieved June 18, 2018.
Archived from the original on February 1, 2015. Archived from the original on February 4, 2015. Archived from the original on February 4, 2015. Archived February 6, 2015. Archived February 6, 2015. Archived February 8, 2015. Archived Feb
 from the original on October 7, 2015. Retrieved October 7, 2015. Archived from the original on February 2, 2013. Retrieved January 29, 2013. Retrieved January 29, 2013. Archived from the original on February 19, 2013.
 Retrieved January 9, 2013. ^ "Office 365 Personal". Office 365 Portal. Microsoft. Archived from the original on February 12, 2013. Retrieved February 3, 2013. ^ a b "The new Office 365 subscriptions for
consumers and small businesses". Microsoft.com. Archived from the original on September 24, 2013. A b Paul Thurrott (March 10, 2022). "Office 2013 Public Preview: Office 365 for Home and Businesses | Office content from Paul Thurrott (March 10, 2022). "Office 2013 Public Preview: Office 365 for Home and Businesses | Office 365 for Home and Bu
October 23, 2012. Retrieved November 21, 2012. ^ "Microsoft Office Home Premium 2013 Preview - Official Site". Microsoft.com. Archived from the original on January 30, 2013. Retrieved November 21, 2012. ^ Arar, Yardena Arar (February 27, 2013). "Decoded: Microsoft's puzzling Office 365 rollout". PC World. IDG. Archived from the original on
July 24, 2014. Retrieved July 24, 2014. ^ "Thurrott, Paul (May 8, 2013). "The Office 365 Upgrade: From Small Business Premium". Microsoft Office website. Microsoft. Archived from the
original on July 26, 2014. Retrieved July 24, 2014. ^ "Microsoft Home Use Program - Microsoft Home Use 
for Personal Computers--standard system requirements. Archived from "Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose,
even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution — You must give appropriate credit, provide a link to the licensor endorses you or your use. ShareAlike — If you
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the public domain or where your use is permitted by an applicable exception or limitation. No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Earlier this week, Microsoft released the final
version of Microsoft Office 2013 to MSDN and TechNet subscribers. By now many of you might have installation, you need to enter the key and activate
your product. Office 2013 is compatible with only Windows 7 and Windows 8 operating systems. Vista and XP users need to upgrade to Windows 8 to experience the newest version of Office 2013 setup, just follow the given below steps to activate your Copy of Office 2013 Step
 1: Once installed, run Office Word, Excel or any other program. You will immediately see Activate Office dialog. Step 2: Click Enter a product key and then click Account to see Product Activated message on the
right-hand side. Updated: January 17, 2024 By Melissa Eggleston You may need to reset your computer, or just want o reinstall your Office 2013 application, or move it to a different computer. But unfortunately, before doing this, you may find that you forget or lost the product key. How to find back Office 2013 lost Product key? Here are two
methods to retrieve your Office 2013 activation key after installing on PC device. Guide Steps Find your Office 2013 Product Key from Office Account page 1. Get into your Office account page with the related Microsoft account used to
install or activate Office 2013. 2. Select the tap of Office 2013, and view the product key by this way: choose Install from a disc > I have a disc > View your product key will be showed below. Identify the product key that was used on your computer If
you are not sure whether the product key is associated with your PC, you can check the last five characters through Command Prompt, and then match it up to the full 25-character product key. To check your Office 2013 last five characters of product key. To check your PC, open Command Prompt. 2. Type the appropriate script to Command
 Prompt, and press Enter to run it. Scripts to find Office 2013 product key on your computer: For 32-bit Office and 64-bit Windows: cscript "C:\Program Files (x86)\Microsoft Office\Office15\OSPP.VBS" /dstatus For 64-bit Office and 64-bit
Windows: cscript "C:\Program Files\Microsoft Office 2013 product key you find from your Office account page, and then you won't make it wrong. Reference from: Retrieve your Office 2013
activation key in registry If you didn't associate your Office account, you may not be able to find it from your Office account page. Try to check it from registry. HKEY LOCAL MATHINE \Software\Microsoft \WindowsNT\CurrentVersion \DigitalProductID. In fact, you can't read the product key directly from registry.
because it is in the binary format. But you can read it with a Product Key Tuner and install it on your computer. 2. On the Product Key Tuner to run. 3. On the Product Key Tuner program, click on Start Recovery button and
begin to recover your Office 2013 product key from the list easily. Yes, it is so easy, just have a try. Related Articles 64-bit version of x86 architecture "Intel 64" redirects here. For the Intel 64-bit architecture in
Itanium chips, see IA-64. "x64" redirects here. For the New York City bus route, see X64 (New York City bus, AMD Opteron, the first CPU to introduce the x86-64 Architecture Programmer's Manual, as published and distributed by AMD in 2002 x86-64 (also known as x64, x86 64, AMD64,
and Intel 64)[note 1] is a 64-bit extension of the x86 instruction set. It was announced in 1999 and first available in the AMD Opteron family in 2003. It introduces two new operating modes: 64-bit mode, x86-64 supports significantly larger amounts of virtual
memory and physical memory compared to its 32-bit predecessors, allowing programs to utilize more memory for data storage. The architecture expands the number of general-purpose registers from 8 to 16, all fully general-purpose, and extends their width to 64 bits. Floating-point arithmetic is supported through mandatory SSE2 instructions in 64-
bit mode. While the older x87 FPU and MMX registers are still available, they are generally superseded by a set of sixteen 128-bit vector registers (XMM registers). Each of these vector registers can store one or two double-precision floating-point numbers, up to four single-precision floating-point numbers, or various integer formats. In 64-bit mode,
instructions are modified to support 64-bit operands and 64-bit addressing mode. The x86-64 architecture defines a compatibility mode that allows 16-bit applications, provided the 64-bit operating system supports them.[11][note 2] Since the full x86-32 instruction sets remain
implemented in hardware without the need for emulation, these older executables can run with little or no performance penalty, [13] while newer or modified applications can take advantage of new features of the processor design to achieve performance improvements. Also, processors supporting x86-64 still power on in real mode to maintain
backward compatibility with the original 8086 processor, as has been the case with x86 processors since the introduction of protected mode with the 80286. The original specification, created by AMD, Intel, and VIA. The AMD K8 microarchitecture, in the Opteron and Athlon 64 processors, was the
first to implement it. This was the first significant addition to the x86 architecture designed by a company other than Intel. Intel was forced to follow suit and introduced x86-64 in their VIA Isaiah architecture, with the VIA Nano. The x86-
64 architecture was quickly adopted for desktop and laptop personal computers and servers which were commonly configured for 16 GiB (gibibytes) of memory or more. It has effectively replaced the discontinued Intel Itanium architecture (formerly IA-64), which was originally intended to replace the x86 architecture. x86-64 and Itanium are not
compatible on the native instruction set level, and operating systems and applications compiled for one architecture and documentation as "AMD 64-bit Technology" and "AMD x86-64 Architecture") was created as an alternative to the
radically different IA-64 architecture designed by Intel and Hewlett-Packard, which was backward-incompatible with IA-32, the 32-bit version of the x86 architecture. AMD originally announced AMD64 in 1999[14] with a full specification available in August 2000.[15] As AMD was never invited to be a contributing party for the IA-64 architecture and
any kind of licensing seemed unlikely, the AMD64 architecture was positioned by AMD from the beginning as an evolutionary way to add 64-bit computing legacy 32-bit x86 code, as opposed to Intel's approach of creating an entirely new, completely x86-incompatible 64-bit architecture
with IA-64. The first AMD64-based processor, the Opteron, Athlon 64 X2, Athlon 64 X2, Athlon 64 X2, Sempron ("Palermo" E6 stepping
and all "Manila" models), Phenom (followed by "X3" or "X4" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom (followed by "X3", "X4" or "X6" to indicate the number of cores), Phenom (followed by "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X3", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X2", "X4" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X3" or "X6" to indicate the number of cores), Phenom II (followed by "X6" to indicate the number of cores), Phenom II (followed by "X6" to indicate the number of cores), Phenom II (followed by "X6" to indicate the number of cores), Phenom II (followed by "X6" to indicate the number of cores), Phenom II (followed by "X6" to indicate
arithmetic and logical operations, and 64-bit virtual addresses, [16] The designers took the opportunity to make other improvements as well. Notable changes in the 64-bit extensions include: 64-bit virtual addresses, [16] The designers took the opportunity to make other improvements as well. Notable changes in the 64-bit virtual addresses, [16] The designers took the opportunity to make other improvements as well.
and register-to-memory operations, etc., can operate directly on 64-bit integers. Pushes and pops on the stack default to 8-byte strides, and pointers are 8 bytes wide. Additional registers is increased from eight (i.e. eax, ebx, ecx, edx,
esi, edi, esp, ebp) in x86 to 16 (i.e. rax, rbx, rcx, rdx, rsi, rdi, rsp, rbp, r8, r9, r10, r11, r12, r13, r14, r15). It is therefore possible to keep more local variables in registers hold frequently accessed constants; arguments for small and fast subroutines may also be passed in registers to a greater extent. AMD64
still has fewer registers than many RISC instruction sets (e.g., Power ISA has 32 GPRs; 64-bit ARM, RISC-V I, SPARC, Alpha, MIPS, and PA-RISC have 31) or VLIW-like machines such as the IA-64 (which has 128 registers). However, an AMD64 implementation may have far more internal registers than the number of architectural registers exposed by
the instruction set (see register renaming). (For example, AMD Zen cores have 168 64-bit integer and 160 128-bit XMM registers (used for Streaming SIMD instructions) is also increased from 8 to 16. The traditional x87 FPU register
stack is not included in the register file size extension in 64-bit mode, compared with the XMM registers used by SSE2, which did get extended. The x87 register file although it does allow direct access to individual registers by low cost exchange operations. Larger virtual address space The AMD64 architecture defines a
64-bit virtual address format, of which the low-order 48 bits are used in current implementations. [11]: 1:20 This allows up to 256 TiB (248 bytes) of virtual address space. The architecture definition allows this limit to be raised in future implementations to the full 64 bits, [11]: 2:3:13:117:120 extending the virtual address space to 16 EiB (264 bytes).
[17] This is compared to just 4 GiB (232 bytes) for the x86.[18] This means that very large files can be operated on by mapping the entire file into the process's address space (which is often much faster than working with file read/write calls), rather than having to map regions of the file into and out of the address space. Larger physical address space
The original implementation of the AMD64 architecture implementations of the AMD64 architecture (starting from AMD 10h microarchitecture) extend this to 48-bit physical addresses [19] and therefore can address up to 256 TiB (248 bytes)
of RAM. The architecture permits extending this to 52 bits in the future[11]:24[20] (limited by the page table entry format);[11]:131 this would allow address Extension (PAE) mode,[21] or 4 GiB of RAM without PAE mode.[11]:4 Larger
physical address space in legacy mode When operating in legacy mode the AMD64 architecture supports Physical address Extension (PAE) mode, as do most current x86 processors, but AMD64 extends PAE from 36 bits to an architectural limit of 52 bits of physical address. Any implementation, therefore, allows the same physical address limit as
under long mode.[11]:24 Instruction pointer relative data access Instruction pointer relative data access Instruction pointer (RIP register). This makes position-independent code, as is often used in shared libraries and code loaded at run time, more efficient. SSE instructions The original AMD64 architecture adopted Intel's SSE and SSE2
as core instructions. These instruction sets provide a vector supplement to the scalar x87 FPU, for the single-precision and double-precision and double-precision and double-precision and double-precision and double-precision and double-precision and double-precision.
processors of its time. These instructions can also be used in 32-bit mode. The proliferation of 64-bit processors has made these vector capabilities ubiquitous in home computers, allowing the improvement of the standards of 32-bit applications. The 32-bit applications. The 32-bit applications of Windows 8, for example, requires the presence of SSE2 instructions. [22] SSE3
instructions and later Streaming SIMD Extensions instruction sets are not standard features of the architecture. No-Execute bit or NX bit (bit 63 of the page table entry) allows the operating system to specify which pages of virtual address space can contain executable code and which cannot. An attempt to execute code from a
page tagged "no execute" will result in a memory access violation, similar to an attempt to write to a read-only page. This should make it more difficult for malicious code to take control of the system via "buffer overrun" or "unchecked buffer" attacks. A similar feature has been available on x86 processors since the 80286 as an attribute of segment
descriptors; however, this works only on an entire segment at a time. Segmented addressing has long been considered an obsolete mode of operation, and all current PC operation as it, setting all segments to a base address of zero and (in their 32-bit implementation) a size of 4 GiB. AMD was the first x86-family vendor to
implement no-execute in linear addressing mode. The feature is also available in legacy mode on AMD64 processors, when PAE is used. Removal of older features A few "system programming" features of the x86 architecture were either unused or underused in modern operating systems and are either not available on
AMD64 in long (64-bit and compatibility) mode, or exist only in limited form. These include segmented addressing (although the FS and GS segments are retained in vestigial form for use as extra-base pointers to operating system structures),[11]:70 the task state switch mechanism, and virtual 8086 mode. These features remain fully implemented in
 "legacy mode", allowing these processors to run 32-bit and 16-bit operating systems without modifications. Some instructions that proved to be rarely useful are not supported in 64-bit mode, including saving/restoring of segment registers on the stack, saving/restoring of all registers (PUSHA/POPA), decimal arithmetic, BOUND and INTO
instructions, and "far" jumps and calls with implementations (diagrams not to scale) Current 48-bit implementations (and all chips that are known to be in the planning stages)
do not allow the entire virtual address space of 264 bytes (16 EiB) to be used. This would be approximately four billion times the size of the virtual address space on 32-bit machines. Most operating systems and applications will not need such a large address space of 264 bytes (16 EiB) to be used. This would be approximately four billion times the size of the virtual address space on 32-bit machines. Most operating systems and applications will not need such a large address space of 264 bytes.
increase the complexity and cost of address translation with no real benefit. AMD, therefore, decided that, in the first implementations of the architecture, only the least significant 48 bits of a virtual address would actually be used in address translation (page table lookup).[11]:120 In addition, the AMD specification requires that the most significant
16 bits of any virtual address, bits 48 through 63, must be copies of bit 47 (in a manner akin to sign extension). If this requirement is not met, the processor will raise an exception. [11]: 131 Addresses run from 0 through 00007FFF'FFFFFFF, and from
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FFFF8000'0000000 through FFFFFFFF, for a total of 256 TiB of usable virtual address space. This is still 65,536 times larger than the virtual 4 GiB address space of 32-bit machines. This feature eases later scalability to true 64-bit addressing. Many operating systems (including, but not limited to, the Windows NT family) take the higher
 addressed half of the address space (named kernel space) for themselves and leave the lower-addressed half (user space) for application code, user mode stacks, heaps, and other data regions. [23] The "canonical address" design ensures that every AMD64 compliant implementation has, in effect, two memory halves: the lower half starts at
0000000000000 and "grows upwards" as more virtual address bits become available, while the higher half is "docked" to the top of the address by checking the unused address bits prevents their use by the operating system in tagged pointers as flags, privilege
markers, etc., as such use could become problematic when the architecture is extended to just 8 TiB of user space and 8 TiB of kernel space. [23] Windows did not support the entire 48-bit address space until
 Windows 8.1, which was released in October 2013.[23] The 64-bit addressing mode ("long mode") is a superset of Physical Address Extensions (PAE); because of 1 GiB (230 bytes).[11]:120 Rather than the three-level page table system used
by systems in PAE mode, systems running in long mode use four levels of page table: PAE's Page-Directory Pointer Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is added, containing 512 entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to 512, and an additional Page-Map Level 4 (PML4) Table is extended from four entries to
 take a bit more than 512 GiB of memory (about 0.195% of the 256 TiB virtual space). 64 bit page table entry Bits: 63 62 ... 52 51 ... 32 Content: Bit 31...12 of base address ign. G PAT D A PCD PWT U/S R/W P Intel has implemented a scheme with a 5-level page
 table, which allows Intel 64 processors to support 57-bit addresses, and in turn, a 128 PiB virtual address space and physical memory with 12-bit page table descriptors and 16- or 21-bit memory offsets for 64 KiB and 2 MiB page allocation sizes; the page table entry would be
expanded to 128 bits to support additional hardware flags for page size and virtual address space size. [25] The operating system can also limit the virtual address space. Details, where applicable, are given in the "Operating system can also limit the virtual address space of up to 248
bytes of RAM, or 256 TiB.[19] However, as of 2020[update], there were no known x86-64 motherboards that support 256 TiB of RAM.[26][27][28][29][failed verification] The operating system compatibility and
characteristics" section of this article. The architecture has two primary modes of operating Coperating System required Type of code being run Size (in bits) No. of general-purpose registers Mode Sub-mode Addresses Operating System required Type of code being run Size (in bits) No. of general-purpose registers Mode Sub-mode Addresses Operating System required Type of code being run Size (in bits) No. of general-purpose registers Mode Sub-mode Addresses Operating System required Type of code being run Size (in bits) No. of general-purpose registers Mode Sub-mode Addresses Operating System required Type of code being run Size (in bits) No. of general-purpose registers Mode Sub-mode Addresses Operating System required Type of code being run Size (in bits) No. of general-purpose registers Mode Sub-mode Su
previous two interacting via a 64-bit firmware, or the latter two interacting via the firmware's UEFI interface 32-bit 32 8, 16, 32 8 Legacy mode Protected mode Bootloader, 32-bit UEFI firmware, or the latter two interacting via the firmware's UEFI interface 32-bit 32 8, 16, 32 8 Legacy mode Protected mode Bootloader, 32-bit UEFI firmware, or the latter two interacting via the firmware's UEFI interface 32-bit 32 8, 16, 32 8
 16-bit protected mode OS 16-bit protected mode OS 16-bit protected mode 16 8, 16, 32[m 1] 8 Virtual 8086 mode 16-bit protected mode or 32-bit OS subset of real mode Bootloader, real mode Bootloader, real mode OS, or any OS interfacing with a firmware's BIOS interface [30] real mode
16, 20, 21 8, 16, 32[m 1] 8 ^ a b c d Note that 16-bit code written for the 80286 and below does not use 32-bit operand instructions. Code written for the 80386 and long mode code for the purpose of using 16-bit operands, as that code would be
running in a code segment with a default operand size of 32 bits. In real mode, the default operand size to 32 bits. State diagram of the x86-64 operation; it is a combination
of the processor's native 64-bit mode and a combined 32-bit and 16-bit protected mode applications (that do not need to use either real mode or virtual 8086 mode in order to execute at any time)
run under compatibility mode. Real-mode programs and programs that use virtual 8086 mode at any time cannot be run in long mode unless those modes are emulated in software.[11]:11 However, such programs may be started from an operating system running in long mode on processors supporting VT-x or AMD-V by creating a virtual processor
running in the desired mode. Since the basic instruction set is the same, there is almost no performance penalty for executing protected mode x86 code. This is unlike Intel's IA-64, where differences in the underlying instruction set mean that running 32-bit code must be done either in emulation of x86 (making the process slower) or with a dedicated
x86 coprocessor. However, on the x86-64 platform, many x86 applications could benefit from a 64-bit recompile, due to the additional registers in 64-bit recompile.
 will need a rewrite of the code handling the huge integers in order to take advantage of the 64-bit registers. Legacy mode is the mode that the processor, and only 16-bit and 32-bit code can be executed. Legacy mode allows for a maximum of 32 bit
virtual addressing which limits the virtual address space to 4 GiB.[11]:14:24:118 64-bit programs cannot be run from legacy mode. [11]:14 Real
mode is the initial mode of operation when the processor is initialized, and is a submode of legacy mode. It is backwards compatible with the original Intel 8086 and Intel 8086 and Intel 8088 processors. Real mode is primarily used today by operating system bootloaders, which are required by the architecture to configure virtual memory details before transitioning
to higher modes. This mode is also used by any operating system that needs to communicate with the system firmware with a traditional BIOS-style interface. [30] Intel 64 is Intel's implementation of x86-64, used and implementation of x86-64.
patterned after Intel's original designs, but with x86-64, roles were reversed: Intel found itself in the position of adopting the ISA that AMD created as an extension to Intel's own x86 processor line. Intel found itself in the position of adopting its existence
 Intel announced at the February 2004 IDF that the project was indeed underway. Intel's chairman at the time, Craig Barrett, admitted that this was one of their worst-kept secrets. [32] (33] Intel's name for this instruction set has changed several times. The name used at the IDF was CT[34] (presumably [original research?] for Clackamas Technology,
another codename from an Oregon river); within weeks they began referring to it as IA-32 extensions) and in March 2004 unveiled the "official" name EM64T (Extended Memory 64 Technology). In late 2006 Intel began instead using the name Intel 64 for its implementation, paralleling AMD's use of the name AMD64.[35] The first
 processor to implement Intel 64 was the multi-socket processor Xeon code-named Nocona in June 2004. In contrast, the initial Prescott chips (February 2004) did not enable this feature. Intel subsequently began selling Intel 64-enabled Pentium 4, model F.
 The E0 revision also adds eXecute Disable (XD) (Intel's name for the NX bit) to Intel 64, and has been included in then current Xeon code-named Irwindale. Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 is name for the NX bit) to Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 is name for the NX bit) to Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 is name for the NX bit) to Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at that time) in mainstream desktop processor implementing Intel 64 (under the name EM64T at the name EM64T at the name EM64T at the
the Merom version of the Core 2 processor, which was released on July 27, 2006. None of Intel's earlier notebook CPUs (Core Duo, Pentium 4, Series, 506, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, Celeron D models 3x1, 3x6, 355, 347, 352, and 516, and 51
360, and 365 and all later Celerons, all models of Xeon since "Nocona", all models of Pentium Dual-Core processors since "Merom-2M", the Atom 230, 330, D410, D425, D510, D525, N450, N470, N475, N550, N570, N2600 and N2800, all versions of the Pentium D, Pentium Extreme Edition, Core 2, Core i9, Core i7, Core i5, and Core i3
 processors, and the Xeon Phi 7200 series processors. X86S was a simplification of x86-64 first proposed by Intel in May 2023.[36] The new architecture would have removed support for 16-bit and 32-bit operating systems, although 32-bit programs would still run under a 64-bit OS. A compliant CPU would have no longer had legacy mode, and started
 directly in 64-bit long mode. There would have been a way to switch to 5-level paging without going through the unpaged mode. Specific removed features included:[37] Segmentation gates 32-bit ring 0 VT-x will no longer emulate this feature Rings 1 and 2 Ring 3 I/O port (IN/OUT) access; see port-mapped I/O String port I/O (INS/OUTS) Real mode
(including huge real mode), 16-bit protected mode, VM86 16-bit addressing mode VT-x will no longer provide unrestricted mode 8259 support; the only APIC supported would be X2APIC Some unused operating system mode bits 16-bit and 32-bit Startup IPI (SIPI) The draft specification received multiple updates, reaching version 1.2 by June 2024. It
was eventually abandoned as of December 2024, following the formation of the x86 Ecosystem Advisory Group by Intel and AMD.[38] Main article: x86 § APX (Advanced Performance Extensions) Advanced Performance Extensions is a 2023 Intel proposal for new instructions and an additional 16 general-purpose registers. VIA Technologies introduced
their first implementation of the x86-64 architecture in 2008 after five years of development by its CPU division, Centaur Technology.[39] Codenamed "Isaiah", the 64-bit architecture was unveiled on January 24, 2008,[40] and launched on May 29 under the VIA Nano brand name.[41] The processor supports a number of VIA-specific x86 extensions
designed to boost efficiency in low-power appliances. It is expected that the Isaiah architecture will be twice as fast in integer performance and four times as fast in floating-point performance and four times as fast in integer performance and four times as fast in floating-point performance and four times as fast in integer performance and four times as fast in floating-point performance and floati
 with thermal design power ranging from 5 W to 25 W.[42] Being a completely new design, the Isaiah architecture was built with support for features like the x86-64 instruction set and x86 virtualization which were unavailable on its predecessors, the VIA C7 line, while retaining their encryption extensions. In 2020, through a collaboration between
AMD, Intel, Red Hat, and SUSE, three microarchitecture levels (or feature levels) on top of the x86-64-v2, x86-64-v2, x86-64-v2, x86-64-v2, x86-64-v2, x86-64-v2, x86-64-v3, and x86-64-v4. [43][44] These levels define specific features that can be targeted by programmers to provide compile-time optimizations. The features exposed by each level are as follows: [45] CPU
microarchitecture levels Level name CPU features Example instruction Supported processors (baseline) and the 2003 AMD AMD64 and the 2004 Intel EM64T initial implementations in the AMD K8 and the Intel Prescott processor families CX8
cmpxchg8b FPU fld FXSR fxsave MMX emms OSFXSR fxsave SCE syscall SSE cvtss2si SSE2 cvtpi2pd x86-64-v2 CMPXCHG16B cmpxchg16b Intel "big" cores AMD Bulldozer and newer Intel "big" cores AMD Jaguar VIA Nano and Eden "C" features match the 2008 Intel
Nehalem architecture, excluding Intel-specific instructions LAHF-SAHF lahf POPCNT popcnt SSE3 addsubpd SSE4 2 pcmpestri SSSE3 pshufb x86-64-v3 AVX vzeroall Intel Haswell and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (AVX2 enabled models only) Intel (Atom) Gracemont and newer Intel "big" cores (Atom) Gracemont and newer Intel "big" cores (Atom) Gr
cores QEMU emulation (as of version 7.2)[46][47] features match the 2013 Intel Haswell architecture, excluding Intel-specific instructions AVX2 vpermd BMI1 and BMI2 bzhi F16C vcvtph2ps FMA vfmadd132pd LZCNT lzcnt MOVBE movbe OSXSAVE xgetbv x86-64-v4 AVX512F kmovw Intel Skylake and newer Intel "big" cores (AVX512 enabled)
models only) AMD Zen 4 and newer AMD cores features match the 2017 Intel Skylake-X architecture, excluding Intel-specific instructions AVX512VL — The x86-64 microarchitecture feature levels can also be found as AMD64-v1, AMD64-v2.. or AMD64 v1. in settings where the
 "AMD64" nomenclature is used. These are used as synonyms with the x86-64-vX nomenclature and are thus functionally identical. Examples of this include features found in the previous levels. Instruction set extensions not concerned with general-purpose
computation, including AES-NI and RDRAND, are excluded from the level requirements. On any x86_64 Linux distribution, all x8
(supported, searched) x86-64-v2 (supported, searched) Here x86-64-v2 (supported by CPU, but x86-64-v2 are, which means this CPU does not support AVX512 required at v4 level. Although nearly identical, there are some differences between the two instruction sets in the semantics of a few seldom used machine
instructions (or situations), which are mainly used for system programming. [48] Unless instructed to otherwise via -march settings, compilers generally produce executables (i.e. machine code) that avoid any differences, at least for ordinary application programs. This is therefore of interest mainly to developers of compilers, operating systems and
 similar, which must deal with individual and special system instructions. Intel 64 allows SYSCALL/SYSRET only in 64-bit mode (not in compatibility mode),[49] and allows SYSENTER/SYSEXIT in both modes.[50] AMD64 lacks SYSENTER/SYSEXIT in both sub-modes of long mode.[11]:33 When returning to a non-canonical address using SYSRET,
AMD64 processors execute the general protection fault handler in privilege level 3,[51] while on Intel 64 processors it is executed in privilege level 0.[52] The SYSRET instruction will load a set of fixed values into the hidden part of SS unchanged on
AMD64.[53] AMD64 requires a different microcode update format and control MSRs (model-specific registers), while Intel 64 lacks some MSRs that are considered architectural in AMD64. These include SYSCFG, TOP MEM, and TOP MEM2. Intel 64 lacks the ability
to save and restore a reduced (and thus faster) version of the floating-point state (involving the FXSAVE and FXRSTOR instructions).[clarification needed] In 64-bit mode, near branches with the 66H (operand size override) prefix behave differently. Intel 64 ignores this prefix: the instruction has a 32-bit sign extended offset, and instruction pointer is
not truncated. AMD64 uses a 16-bit offset field in the instruction, and clears the top 48 bits of instruction pointer. On Intel 64 but not AMD64, the REX.W prefix can be used with the far-pointer instruction pointer. On Intel 64 but not AMD64, the REX.W prefix can be used with the far-pointer instruction pointer. On Intel 64 but not AMD64, the REX.W prefix can be used with the far-pointer instruction pointer.
MOVSXD instruction is executed with a memory source operand and an operand-size of 16 bits, the memory operand will be accessed with a 32-bit read on Intel 64, but a 32-bit read on Intel
flag bits unmodified on AMD64. For the VMASKMOVPS/VMASKMOVPD/VPMASKMOVD/VPMASKMOVD/VPMASKMOVD/VPMASKMOVD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/VPMASKMOVPD/V
such a guarantee. If the RDRAND instruction fails to obtain a random number (as indicated by EFLAGS.CF=0), the destination register is architecturally guaranteed to be set to 0 on Intel 64 but not AMD64. For the VPINSRD and VPEXTRD (AVX vector lane insert/extract) instructions outside 64-bit mode, AMD64 requires the instructions to be
encoded with VEX.W=0, while Intel 64 also accepts encodings with VEX.W=1. (In 64-bit mode, both AMD64 and Intel 64 require VEX.W=0.) The 0F 0D /r opcode with the ModR/M byte's Mod field set to 11b is a Reserved-NOP on Intel 64[54] but will cause #UD (invalid-opcode exception) on AMD64.[55] The ordering guarantees provided by some
memory ordering instructions such as LFENCE and MFENCE differ between Intel 64 and AMD64: LFENCE is dispatch-serializing on AMD64. [56] MFENCE is a fully serializing instruction (including instruction fetch serialization)
on AMD64 but not Intel 64. The MOV to CR8 and INVPCID instructions are serializing on AMD64 but not Intel 64. The LMSW instruction is serializing on Intel 64 but not AMD64. WRMSR to the x2APIC ICR (Interrupt Command Register; MSR 830h) is commonly used to produce an IPI (Inter-processor interrupt) — on Intel 64[57] but not AMD64[58]
CPUs, such an IPI can be reordered before an older memory store. This section needs to be updated. The reason given is: future tense relating to processors that have been out for years, dates with day and month but no year. Please help update this article to reflect recent events or newly available information. (January 2023) The AMD64 processors
prior to Revision F[59] (distinguished by the switch from DDR to DDR2 memory and new sockets AM2, F and S1) of 2006 lacked the CMPXCHG8B instruction, which is an extension of the CMPXCHG8B instruction, which is an extension of the CMPXCHG16B instruction present on most post-80486 processors.
 values). This is useful for parallel algorithms that use compare and swap on data larger than the size of a pointer, common in lock-free and wait-free algorithms. Without CMPXCHG16B one must use workarounds, such as a critical section or alternative lock-free approaches. [60] Its absence also prevents 64-bit Windows prior to Windows 8.1 from
 having a user-mode address space larger than 8 TiB.[61] The 64-bit version of Windows 8.1 requires the instructions (also in 64-bit mode) with their 90 nm (revision D) processors, starting with Athlon 64 in October 2004.[63]
[64] Intel introduced the instructions in October 2005 with the 0F47h and later revisions of Windows 8.1 requires this feature. [62] Early Intel CPUs with Intel 64 also lack the NX bit of the AMD64 architecture. It was added in the stepping E0 (0F41h) Pentium 4 in October 2004. [71] This feature is required by all
 versions of Windows 8. Early Intel 64 implementations had a 36-bit (64 GiB) physical addressing of memory while original AMD64 implementations had a 40-bit (1 TiB) physical addressing. Intel used the 40-bit physical addressing first on Xeon MP (Potomac), launched on 29 March 2005.[72] The difference is not a difference of the user-visible ISAs. In
2007 AMD 10h-based Opteron was the first to provide a 48-bit (256 TiB) physical addressing was extended to 44 bits (16 TiB) in Nehalem-EX in 2010[75] and to 46 bits (64 TiB) in Sandy Bridge E in 2011.[76][77] With the Ice Lake 3rd gen Xeon Scalable processors, Intel increased the virtual addressing to 57
bits (128 PiB) and physical to 52 bits (4 PiB) in 2021, necessitating a 5-level paging.[78] The following year AMD64 added the same in 4th generation EPYC (Genoa).[79] Non-server CPUs retain smaller address spaces for longer. On all AMD64 processors, the BSF and BSR instructions will, when given a source value of 0, leave their destination
register unmodified. This is mostly the case on Intel 64 processors as well, except that on some older Intel 64 CPUs, executing these instructions with an operand size of 32 bits will clear the top 32 bits will clear the top 32 bits will clear the top 32 bits of their destination register even with a source value of 0 (with the low 32 bits kept unchanged.)[80] AMD64 processors since Opteron Rev. E and
Athlon 64 Rev. D reintroduced limited support for segment Limit Enable (LMSLE) bit, to ease virtualization of 64-bit guests. [81] [82] LMLSE support was removed in the Zen 3 processors. [83] On all Intel 64 processors, CLFLUSH is ordered with respect to SFENCE - this is also the case on newer AMD64 processors.
(Zen 1 and later). On older AMD64 processors, imposing ordering on the CLFLUSH instruction instead required MFENCE. An area chart showing the representation of different families of microprocessors in the TOP500 supercomputer ranking list, from 1993 to 2020[84] In supercomputers tracked by TOP500, the appearance of 64-bit extensions for
the x86 architecture enabled 64-bit x86 processors by AMD and Intel to replace most RISC processor architectures previously used in such systems (including PA-RISC, SPARC, Alpha and others), as well as 32-bit x86, even though Intel itself initially tried unsuccessfully to replace x86 with a new incompatible 64-bit architecture in the Itanium
processor. As of 2023[update], a HPE EPYC-based supercomputer called Frontier is number one. The first ARM-based supercomputer appeared on the list in 2018[85] and, in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors, which implement appeared on the list in 2018[85] and in recent years, non-CPU architecture co-processors (GPGPU) have also processors (GPGPU) architecture co-processors (GPGPU)
 subset of x86-64 with some vector extensions,[86] are also used, along with x86-64 processors, in the Tianhe-2 supercomputer.[87] The following operating systems and releases support the x86-64 architecture in long mode. Preliminary infrastructure work was started in February 2004 for a x86-64 port.[88] This development later stalled.
 Development started again during July 2007[89] and continued during Google Summer of Code 2008 and SoC 2009.[90][91] The first official release to contain x86-64 support was version 2.4.[92] FreeBSD first added x86-64 support was version 2.4.[92] FreeBSD first added x86-64 support was version 2.4.[92] The first official release to contain x86-64 support was version 2.4.[92] FreeBSD first added x86-64 support was versio
distribution architecture as of 5.2-RELEASE in January 2004. Since then, FreeBSD has designated it as a Tier 1 platform. The 6.0-RELEASE version cleaned up some quirks with running x86 executables under amd64, and most drivers work just as they do on the x86 architecture. Work is currently being done to integrate more fully the x86 application
 binary interface (ABI), in the same manner as the Linux 32-bit ABI compatibility currently works. x86-64 architecture support was first committed to the NetBSD source tree on June 19, 2001. As of NetBSD 2.0, released on December 9, 2004, NetBSD/amd64 is a fully integrated and supported port. 32-bit code is still supported in 64-bit mode, with a
 netbsd-32 kernel compatibility layer for 32-bit syscalls. The NX bit is used to provide non-executable stack and heap with per-page granularity (segment granularity being used on 32-bit x86). OpenBSD has supported AMD64 support was achieved prior to the
 hardware's initial release because AMD had loaned several machines for the project's hackathon that year. OpenBSD developers have taken to the platform because of its support for the AMD64 port of OpenBSD also runs on Intel 64 processors which contains
 cloned use of the AMD64 extensions, but since Intel left out the page table NX bit in early Intel 64 processors, there is no W^X capability on those Intel CPUs; later Intel 64 processors added the NX bit under the name "XD bit". Symmetric multiprocessing (SMP) works on OpenBSD's AMD64 port, starting with release 3.6 on November 1, 2004. This
 article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. "X86-64" - news · newspapers · books · scholar · JSTOR (December 2022) (Learn how and when to remove this message) It is possible to enter long mode under
DOS without a DOS extender, [93] but the user must return to real mode in order to call BIOS or DOS interrupts. It may also be possible to enter long mode with a DOS extender similar to DOS/4GW, but more complex since x86-64 lacks virtual 8086 mode. DOS itself is not aware of that, and no benefits should be expected unless running DOS in an
 emulation with an adequate virtualization driver backend, for example: the mass storage interface. See also: Comparison of Linux distributions § Instruction set architecture in long mode, starting with the 2.4 version in 2001 (preceding the hardware's availability). [94]
 components and libraries when installing off a 64-bit distribution medium, thus allowing most existing 32-bit applications to run alongside the 64-bit of x82 ABI (Application Binary Interface), introduced in Linux 3.4, allows programs compiled for the x32 ABI (Application Binary Interface), introduced in Linux 3.4, allows programs compiled for the x32 ABI (Application Binary Interface).
[99] Though this limits the program to a virtual address space of 4 GiB, it also decreases the memory footprint of the program and in some cases can allow it to run faster. [97][98][99] 64-bit Linux allows up to 128 TiB of virtual address space for individual processes, and can address approximately 64 TiB of physical memory, subject to processor and
system limitations,[100] or up to 128 PiB (virtual) and 4 PiB (physical) with 5-level paging enabled.[101] Mac OS X 10.4 run 64-bit Intel-based machines, just as all versions of Mac OS X 10.4 and 10.5 run them on 64-bit PowerPC machines. No
other libraries or frameworks work with 64-bit applications in Mac OS X 10.4.[102] The kernel, and all kernel extensions, are 32-bit only. Mac OS X 10.5 supports 64-bit Intel-based machines, as well as on 64-bit PowerPC machines.[103] All non-GUI libraries and frameworks also
 support 64-bit applications on those platforms. The kernel, and all kernel extensions, are 32-bit only. Mac OS X 10.6 is the first version of macOS that supports a 64-bit kernel, and not all 64-bit computers that can run the 64-bit kernel will do so by default. [104] The 64-bit kernel, like the 32 that supports a 64-bit kernel will do so by default.
bit kernel, supports 32-bit applications; both kernel also support 64-bit applications. 32-bit applications are limit of 4 GiB under either kernel does not support 64-bit kernel extensions. OS X 10.8 includes only the 64-bit kernel, but
continues to support 32-bit applications; it does not support 32-bit kernel extensions, however. macOS 10.15 includes only the 64-bit kernel and no longer supports 32-bit applications. This removal of support has presented a problem for Wine (and the commercial version CrossOver), as it needs to still be able to run 32-bit Windows applications. The
 solution, termed wine 32 on 64, was to add thunks that bring the CPU in and out of 32-bit compatibility mode in the nominally 64-bit application and library code into a single file; the most appropriate version is automatically selected at load time. In
Mac OS X 10.6, the universal binary format is also used for the kernel and 64-bit kernels. See also: illumos Solaris 10 and later releases support the x86-64 architecture. For Solaris 10, just as with the SPARC architecture, there is only one operating system image, which contains a 32-bit kernel
and a 64-bit kernel; this is labeled as the "x64/x86" DVD-ROM image. The default behavior is to boot a 64-bit kernel, allowing both 64-bit and existing or new 32-bit executables will run. The isainfo command can be used to determine if a system is running a
64-bit kernel. For Solaris 11, only the 64-bit kernel is provided. However, the 64-bit kernel supports both 32- and 64-bit kernel supports both 32- and system calls. x64 edition—were released in March 2005.[109] Internally they are
actually the same build (5.2.3790.1830 SP1),[110][111] as they share the same source base and operating system binaries, so even system updates are released in unified packages, much in the manner as Windows 2000 Professional and Server editions for x86. Windows Vista, which also has many different editions, was released in January 2007
 Windows 7 was released in July 2009. Windows Server 2008 R2 was sold in only x64 and Itanium editions; later versions of Windows Server 2012 R2 offer the following: 8 TiB of virtual address space per process, accessible from both user mode and
kernel mode, referred to as the user mode address space. An x64 program can use all of this, subject to backing store limits on the system, and provided it is linked with the "large address space offered by 32-bit Windows."
[113][114] 8 TiB of kernel mode virtual address space for the operating system.[113] As with the user mode address space primarily benefits the file system cache and kernel mode "heaps" (non-paged pool). Windows only uses a total of 16 TiB out of the
256 TiB implemented by the processors because early AMD64 processors lacked a CMPXCHG16B instruction.[115] Under Windows 8.1 and Windows Server 2012 R2, both user mode and kernel mode virtual address spaces have been extended to 128 TiB.[23] These versions of Windows will not install on processors that lack the CMPXCHG16B
virtual address space in 64-bit Windows, instead of the default 2 GiB (optional 3 GiB with /3GB boot option on x86, this does not reduce the kernel mode virtual address space available to the operating system. 32-bit applications can,
therefore, benefit from running on x64 Windows even if they are not recompiled for x86-64. Both 32- and 64-bit applications, if not linked with "large address space. Ability to use up to 128 GiB (Windows 8), 1 TiB (Windows 8), 2 TiB (Windows 8), 3 TiB (Windows 8), 2 TiB (Windows 8), 3 TiB (Windows
Server 2008/Windows 10), 4 TiB (Windows Server 2016/2019) of physical random access memory (RAM).[117] LLP64 data model: in C/C++, "int" and "long" types are 32 bits wide, "long long" is 64 bits, while pointers and types derived from pointers are 64 bits wide. Kernel mode device drivers must be 64-bit
versions; there is no way to run 32-bit kernel mode executables within the 64-bit operating system. User mode device drivers can be either 32-bit or 64-bit. 16-bit Windows (Win16) and DOS applications will not run on x86-64 versions of Windows due to the removal of the virtual DOS machine subsystem (NTVDM) which relied upon the ability to use
virtual 8086 mode. Virtual 8086 mode. Virtual 8086 mode cannot be entered while running in long mode. Full implementation of the Windows when they are started in PAE mode. Instead of FS segment descriptor on x86 versions of the Windows NT family, GS segment
descriptor is used to point to two operating system defined structures: Thread Information Block (NT_TIB) in user mode GS:0 is the address of the first member of the Thread Information Block. Maintaining this convention made the x86-64 port easier, but required
AMD to retain the function of the FS and GS segments in long mode - even though segmented addressing per se is not really used by any modern operating system. [113] Early reports claimed that the operating system scheduler would not save and restore the x87 FPU machine state across thread context switches. Observed behavior shows that this
 is not the case: the x87 state is saved and restored, except for kernel mode-only threads (a limitation that exists in the 32-bit version as well). The most recent documentation available from Microsoft states that the x87/MMX/3DNow! instructions may be used in long mode, but that they are deprecated and may cause compatibility problems in the
 future.[116] (3DNow! is no longer available on AMD processors, with the exception of the PREFETCH and PREFETCHW instructions,[118] which are also supported on Intel processors as of Broadwell.) Some components like Jet Database Engine and Data Access Objects will not be ported to 64-bit architectures such as x86-64 and IA-64.[119][120]
[121] Microsoft Visual Studio can compile native applications to target either the x86-64 architecture, which can run as a 32-bit Microsoft Windows or 64-bit Microsoft Windows in WoW64 emulation mode. Managed applications can be compiled either in
 IA-32, x86-64 or AnyCPU modes. Software created in the first two modes behave like their IA-32 or x86-64 native code counterparts respectively; When using the AnyCPU mode, however, applications in 32-bit versions of Microsoft Windows. The
 accelerated processing unit (APU) based on the Zen 2 microarchitecture. [126] Since AMD64 and Intel 64 are substantially similar, many software and hardware products use one vendor-neutral term to indicate their compatibility with both implementations. AMD's original designation for this processor architecture, "x86-64", is still used for this
purpose, [2] as is the variant "x86 64". [3][4] Other companies, such as Microsoft [6] and Sun Microsystems/Oracle Corporation, [5] use the contraction "x64" in marketing material. The term IA-64 refers to the Itanium processor, and should not be confused with x86-64, as it is a completely different instruction set. Many operating systems and products,
especially those that introduced x86-64 support prior to Intel's entry into the market, use the term "AMD64" or "amd64" to refer to both AMD64 and Intel 64 under the architecture name "amd64". Some Linux distributions such as
Debian, Ubuntu, Gentoo Linux refer to both AMD64 and Intel 64 under the architecture name "amd64". Microsoft Windows's x64 versions use the AMD64 moniker internally to designate various components which use or are compatible with this architecture. For example, the environment variable PROCESSOR ARCHITECTURE is assigned the value
"AMD64" as opposed to "x86" in 32-bit versions, and the system directory on a Windows x64 Edition installation CD-ROM is named "AMD64-, in contrast to "i386" in 32-bit versions, and the system directory on a Windows x64 Edition installation CD-ROM is named "AMD64- and Intel 64-based systems as "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "AMD64- and Intel 64-based systems as "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "AMD64- and Intel 64-based systems as "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "amd64". Java Development Kit (JDK): the name "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "amd64". Java Development Kit (JDK): the named "amd64" is used in directory on a Windows x64 Edition installation CD-ROM is named "amd64".
names containing x86-64 files. x86 64 The Linux kernel[128] and the GNU Compiler Collection refers to 64-bit architecture as "x86 64". Apple macOS refers to 64-bit architecture as "x86 64". Some Linux distributions, such as Fedora, openSUSE, Arch Linux refer to this 64-bit architecture as "x86 64".
Terminal command arch[3] and in their developer documentation.[2][4] Breaking with most other BSD systems, DragonFly BSD refers to 64-bit architecture as "x86 64". x86-64/AMD64 was solely developed by AMD. Until April 2021 when the relevant patents expired, AMD held patents on techniques
 used in AMD64;[129][130][131] those patents had to be licensed from AMD in order to implement AMD64. Intel entered into a cross-licensing agreement with AMD, licensing to AMD their patents on existing x86 techniques, and licensing to AMD their patents on existing x86 techniques.
cross-licensing disagreements, extending their cross-licensing agreements. [133][134][135] AGESA (AMD Generic Encapsulated Software Architecture) Transient execution CPU vulnerability ^ Various names are used for the instruction set. Prior to the launch, x86-64 and x86_64 were used, while upon the release AMD named it AMD64.[1] Intel
initially used the names IA-32e and EM64T before finally settling on "Intel 64" for its implementation. Some in the industry, including Apple, [2][3][4] use x86-64 and x86_64, while others, notably Sun Microsystems[5] (now Oracle Corporation) and Microsoft, [6] use x64. The BSD family of OSs and several Linux distributions[7][8] use AMD64, as does
Microsoft Windows internally.[9][10] ^ In practice, 64-bit operating systems generally do not support 16-bit applications, although modern versions of Microsoft ACME installers by silently substituting them with 32-bit code.[12] ^ The Register reported
that the stepping G1 (0F49h) of Pentium 4 will sample on October 17 and ship in volume on November 14.[68] However, Intel's document says that samples are available on September 9, whereas October 17 is the "date of first availability of post-conversion material", which Intel defines as "the projected date that a customer may expect to receive the
post-conversion materials.... customers should be prepared to receive the post-converted materials on this date".[69] ^ "Debian AMD64 FAQ". Debian Wiki. Archived from the original on June 2, 2012. Retrieved November 23, 2012. ^ a b c
arch(1) - Darwin and macOS General Commands Manual ^ a b c Kevin Van Vechten (August 9, 2006). "re: Intel XNU bug report". Darwin-dev mailing list. Apple Computer. Archived from the original on February 1, 2020. Retrieved October 5, 2006. The kernel and developer tools have standardized on "x86_64" for the mane of the Mach-O architecture
 a b "Solaris 10 on AMD Opteron". Oracle. Archived from the original on July 25, 2017. Retrieved December 9, 2010. a b "Microsoft 64-Bit Computing". Microsoft 64-Bit Computing". Debian. Archived from the original on September 26, 2019. Retrieved November 23, 2010.
2012. ^ "Gentoo/AMD64 Project". Gentoo Project. Archived from the original on June 3, 2013. Retrieved January 24, 2016. ^ "ProcessorArchitecture Class". Archived from the original on June 3, 2017. Retrieved January 24, 2016. ^ a b c d e f g
h i j k l m n o p q r s t u AMD Corporation (December 2016). "Volume 2: System Programming" (PDF). AMD64 Architecture Programmer's Manual. AMD Corporation (December 31, 2013). "If there is no 16-bit emulation layer in 64-bit Windows, how come
certain 16-bit installers are allowed to run?". Archived from the original on July 14, 2021. Retrieved April 9, 2010. Figures 5, 6 and 7 also show the
 32-bit version of WAS runs applications at full native hardware performance on the POWER and x86-64 platforms. Unlike some 64-bit processor architectures, the POWER and x86-64 hardware does not emulate 32-bit wersion of
 WebSphere running on the above mentioned 64-bit platforms. ^ "AMD Discloses New Technologies At Microporcessor Forum" (Press release). AMD. October 5, 1999. Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. Retrieved November 9, 2010. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. ^ "AMD Releases x86-64 Archived from the original on March 8, 2012. ^ "AMD Releases x86-64 Archived from the origina
(Press release). AMD. August 10, 2000. Archived from the original on March 8, 2012. Retrieved November 9, 2010. AMD64 Architecture. John Wiley & Sons. "Intel 64 and IA-32 Architectures Software Developer's Manual, Volume 3A: System
Programming Guide, Part 1" (PDF). pp. 4-7. Archived (PDF) from the original on April 18, 2016. Retrieved February 27, 2016. Physical address space increased to 48 bits.
 "Myth and facts about 64-bit Linux" (PDF). March 2, 2008. p. 7. Archived from the original (PDF) on October 10, 2010. Retrieved May 30, 2010. Physical address space increased to 48 bits Shanley, Tom (1998). Pentium Pro and Pentium II System Architecture. PC System Architecture Series (Second ed.). Addison-Wesley. p. 445. ISBN 0-201-30973-
 4. ^ Microsoft Corporation. "What is PAE, NX, and SSE2 and why does my PC need to support them to run Windows 8?". Archived from the original on April 11, 2013. Archived from the original on January 6, 2014. Retrieved January
20, 2014. ^ "5-Level Paging and 5-Level EPT" (PDF). Intel. May 2017. Archived (PDF) from the original on December 5, 2018. Retrieved June 17, 2017. ^ US patent 9858198, Larry Seiler, "64KB page system that supports 4KB page operation", published December 29, 2016, issued January 2, 2018, assigned to Intel Corp. ^ "Opteron 6100 Series
Motherboards". Supermicro Corporation. Archived from the original on June 3, 2010. Retrieved June 22, 2010. ^ "Opteron 8000 Series Motherboards". Supermicro Corporation. Archived from the original on May 27, 2010.
Retrieved June 20, 2010. ^ "Tyan Product Matrix". MiTEC International Corporation. Archived from the original on October 25, 2021. Retrieved October 25, 2021. ^
 "Intel is Continuing the Yamhill Project?". Neowin. Archived from the original on June 5, 2022. Retrieved June 5, 2022. ^ "Craig Barrett confirms 64 bit address extensions for Xeon. And Prescott". The Inquirer. February 17, 2004. Archived from the original on January 12, 2013. Retrieved August 20, 2017. ^ ""A Roundup of 64-Bit Computing", from
 internetnews.com". Archived from the original on September 25, 2012. Retrieved September 18, 2006. ^ Lapedus, Mark (February 6, 2004). "Intel to demo 'CT' 64-bit processor line at IDF". EDN. AspenCore Media. Archived from the original on June
29, 2011. Retrieved June 29, 2007. ^ "Intel Publishes "X86-S" Specification For 64-bit Only Architecture". www.phoronix.com. ^ "Envisioning a Simplified Intel Architecture" to de-bloat x86 instruction set comes to an end". Tom's Hardware.
 Retrieved December 20, 2024. ^ "VIA to launch new processor architecture in 1Q08" (subscription required). DigiTimes. July 25, 2007. Archived from the original on December 3, 2008. Retrieved July 25, 2007. Archived from the original on January 23, 2008.
27, 2008. Retrieved January 24, 2008. ^ "VIA Launches VIA Nano Processor Family" (Press release). VIA. May 29, 2008. Archived from the original on February 3, 2019. Retrieved May 25, 2017. ^ "VIA Isaiah Archived from the original on February 3, 2019. Retrieved May 25, 2017. ^ "VIA Isaiah Archived from the original on February 3, 2019. Retrieved May 25, 2017. ^ "VIA Isaiah Archived from the original on February 3, 2019. Retrieved July 31, 2013. ^
 Weimer, Florian (July 10, 2020). "New x86-64 micro-architecture levels". llvm-dev (Mailing list). Archived from the original on April 14, 2021. Retrieved March 11, 2021. Archived from the original on February 5, 2021). "Building Red Hat Enterprise Linux 9 for the x86-64-v2 microarchitecture levels". Red Hat developer blog. Archived from the original on February 5, 2021.
20, 2022. Retrieved March 22, 2022. ^ "System V Application Binary Interface Low Level System Information". x86-64 psABI repo. January 29, 2021. Archived from the original on February 2, 2021. Retrieved March 11, 2021 - via GitLab. ^ "QEMU version 7.2.0 released - QEMU". www.qemu.org. Archived from the original on December 21, 2022.
 Retrieved January 9, 2023. ^ "ChangeLog/7.2 - QEMU". wiki.qemu.org. Archived from the original on January 9, 2023. Retrieved January 9, 2023. ^ Wasson, Scott (March 23, 2005). "64-bit computing in theory and practice". The Tech Report. Archived from the original on March 12, 2011. Retrieved March 22, 2011. ^ "Intel 64 and IA-32".
Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2013. pp. 4-397. Architectures Software Developer's Software Developer's Software Developer's Software Developer's So
(PDF). Intel. September 2013. pp. 4-400. Archived (PDF) from the original on October 20, 2013. Retrieved August 2, 2014. ^ "AMD64 Architecture Programmer's Manual Volume 3: General-Purpose and System Instructions" (PDF). AMD. May 2018. p. 419. Archived (PDF) from the original on August 20, 2018. Retrieved August 2, 2018. ^ "Intel 64"
and IA-32 Architectures Software Developer's Manual Volume 2 (2A, 2B & 2C): Instruction Set Reference, A-Z" (PDF). Intel. September 2014. pp. 4-412. Archived (PDF) from the original on January 13, 2015. Retrieved December 28, 2014. ^ LKML, (PATCH) x86_64, asm: Work around AMD SYSRET SS descriptor attribute issue, 23 Apr 2015. ^ Intel.
 Intel 64 and IA-32 Architectures Software Developer's Manual, volume 3B, order no. 253669-086US, December 2024, chapter 24.15, page 426. Architectures Software Developer's Manual Volume 3B, order no. 24594, rev 3.36, March 2024, see description of PREFETCHW
instruction on page 283. Archived on 29 Dec 2024. Archived on 29 Dec 2024. Archived on 10 Jun 2023. LKML, (PATCH 5.4 55/65) x86/apic: Add extra serialization for non-serializing MSRs, 8 Feb 2021. Linux kernel, git commit: x86/barrier: Do not serialize MSR accesses on AMD, 13 Nov 2023.
 "Live Migration with AMD-V" Extended Migration Technology" (PDF). developer.amd.com. Archived (PDF) from the original on December 6, 2022. Retrieved June 30, 2022. Retrieved June 30, 2022. A Maged M. Michael. "Practical Lock-Free and Wait-Free LL/SC/VL Implementations Using 64-Bit CAS" (PDF). IBM. Archived (PDF) from the original on May 2, 2013. Retrieved
 January 21, 2014. ^ darwou (August 20, 2004). "Why is the virtual address space 4GB anyway?". The Old New Thing. Microsoft. Archived from the original on April 28, 2014. Retrieved April 27, 2014. To install a 64-bit OS on a 64-
 bit PC, your processor needs to support CMPXCHG16b, PrefetchW, and LAHF/SAHF. Petkov, Borislav (August 10, 2009). "Re: [PATCH v2] x86: clear incorrectly forced X86_FEATURE_LAHF_LM flag". Linux kernel mailing list. Archived from the original on January 11, 2023. Retrieved June 30, 2022. "Revision Guide for AMD Athlon 64 and AMD
Opteron Processors" (PDF). AMD. Archived (PDF) from the original on August 24, 2009. ^ "Product Change Notification 105224 - 01" (PDF). Intel. Archived from the original on August 24, 2009. ^ "Intel. Pentium." Processor 800 Sequence and Intel. Processor Extreme Edition 840 Specification
 Archived from the original on June 30, 2022. Retrieved June 30, 2022. A "Product Change Notification 105271 - 00" (PDF). Intel. Archived from the original (PDF) on November 17, 2005. OF47h debuted in the B0 stepping of Pentium D on October 21,[65][66] but 0F48h which also supports LAHF/SAHF launched on October 10 in the dual-core Xeon
[67][a] ^ "Product Change Notification 104101 - 00" (PDF). Intel. Archived from the original (PDF) on July 16, 2004. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. Retrieved November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. Retrieved November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the original on November 17, 2022. ^ "Justin Boggs's at Microsoft PDC 2008". p. 5. Archived from the Original Origin PDC 2008". p. 5. Archived from the Origin 
2022. Retrieved November 17, 2022. ^ "Intel 64 and IA-32 Architectures Software Developer's Manual". September 2014. p. 2-21. Archived from the original on May 14, 2019. Intel 64 and IA-32 Architectures Software Developer's Manual". September 2014. p. 2-21. Archived from the original on May 14, 2019. Intel 64 and IA-32 Architectures Software Developer's Manual".
Core i7-3960X Review". Archived from the original on May 26, 2016. Retrieved July 1, 2022. A Kennedy, Patrick (November 10, 2022). "AMD EPYC Genoa
Gaps Intel Xeon in Stunning Fashion". ServeTheHome. p. 2. Archived from the original on November 17, 2022. Archived from the original on November 18, 2022. Archived from the original on November 18, 2022. Archived from the original on November 19, 2022. Archived from the original o
Archived on 1 Jan 2025. Thow retiring segmentation in AMD64 long mode broke VMware. Archived from the original on July 18, 2011. Retrieved May 2, 2010. Thou retiring segmentation in AMD64 long mode broke VMware. Archived from the original on July 18, 2011. Retrieved May 2, 2010. Thou retiring segmentation in AMD64 long mode broke VMware and CPU Virtualization Technology.
  Linux-Kernel Archive: [PATCH 2/5] KVM: sym: Disallow EFER.LMSLE on hardware that doesn't support it", lkml.indiana.edu, Retrieved November 3, 2023, "Statistics | TOP500 Supercomputer Sites", Top500.org, Archived from the original on March 19, 2014, Retrieved March 22, 2014,
www.top500.org. Archived from the original on December 7, 2018. Retrieved December 7, 2018. Retrieved December 7, 2018. Retrieved May 21, 2014. Retrieved May 21
2014. ^ "Intel Powers the World's Fastest Supercomputer, Reveals New and Future High Performance Computing Technologies". Archived from the original on June 22, 2013. Retrieved June 21, 2013. ^ "cvs commit: src/sys/amd64/amd64 genassym.c src/sys/amd64/include asm.h atomic.h bootinfo.h coredump.h cpufunc.h elf.h endian.h exec.h float.h
fpu.h frame.h globaldata.h ieeefp.h limits.h lock.h md var.h param.h pcb.h pcb ext.h pmap.h proc.h profile.h psl.h ..." Archived from the original on May 18, 2010. Retrieved May 3, 2009. ^ "DragonFlyBSD: GoogleSoC2008". Archived from the original on April
27, 2009. Retrieved May 3, 2009. "Summer of Code accepted students". Archived from the original on September 4, 2010. Retrieved May 3, 2009. "Tutorial for entering protected and long mode from DOS". Archived from the original on
February 22, 2017. Retrieved July 6, 2008. And Kleen (June 26, 2001). "Porting Linux to x86-64". Archived from the original on September 10, 2010. Status: The kernel boots and work on simulator and is used for porting of userland and running programs. And Kleen. "And Kleen (June 26, 2001). "Porting Linux to x86-64". Archived from the original on September 10, 2010. Status: The kernel boots and work on simulator and is used for porting of userland and running programs."
original on December 7, 2009. Retrieved August 21, 2009. This was the original paper describing the Linux x86-64 kernel port back when x86-64 kernel port back wh
Thorsten Leemhuis (September 13, 2011). "Kernel Log: x32 ABI gets around 64-bit drawbacks". www.h-online.com. Archived from the original on October 28, 2011. Retrieved November 1, 2011. ^ a b "x32-abi"
Google Sites. Archived from the original on October 30, 2011. A "AMD64 Port". debian.org. Retrieved February 7, 2024. A "Apple - Mac OS X Xcode 2.4 Release Notes: Compiler Tools". Apple Inc. April 11,
2007. Archived from the original on April 22, 2009. Retrieved November 19, 2012. ^ "Apple Inc. Archived from the original on January 12, 2009. Retrieved November 19, 2012. ^ "Mac OS X v10.6: Macs that use the 64-bit kernel". Apple Inc. Archived from the original on August 31, 2009. Retrieved November 19, 2012. ^ "Mac OS X v10.6: Macs that use the 64-bit kernel". Apple Inc. Archived from the original on August 31, 2009. Retrieved November 19, 2012. ^ "Mac OS X v10.6: Macs that use the 64-bit kernel".
November 29, 2012. ^ John Siracusa. "Mac OS X 10.6 Snow Leopard: the Ars Technica review". Ars Technica LLC. Archived from the original on March 28, 2011. Retrieved November 19, 2012. ^ Schmid, J; Thomases, K; Ramey, J; Czekalla,
U; Mathieu, B; Abhiram, R (September 10, 2019). "So We Don't Have a Solution for Catalina...Yet". CodeWeavers Blog. Archived from the original on November 11, 2020. Retrieved September 29, 2021. A chived from the original on November 11, 2020. Retrieved September 29, 2021.
2021. ^ "Microsoft Raises the Speed Limit with the Availability of 64-Bit Editions of Windows XP Professional x64 Edition". Microsoft Raises the Speed Limit with the Availability of 64-Bit Editions of Windows XP Professional x64 Edition". Microsoft Raises the Speed Limit with the Availability of 64-Bit Editions of Windows XP Professional x64 Editions.
Support. Archived from the original on April 20, 2016. Retrieved August 14, 2016. ^ a b "/LARGEADDRESSAWARE (Handle Large Addresses)". Visual Studio 2022 Documentation - MSVC
 Linker Reference - MSVC Linker Options. Microsoft. Archived from the original on December 21, 2022. Retrieved December 21, 2022. The /LARGEADDRESSAWARE option tells the linker that the application can handle addresses larger than 2 gigabytes. ^ a b c Matt Pietrek (May 2006). "Everything You Need To Know To Start Programming 64-Bit
Windows Systems". Microsoft. Retrieved April 18, 2023. ^ "Behind Windows x86-64's 44-bit Virtual Memory Addressing Limit". Archived from the original on December 23, 2008. Retrieved July 2, 2009. ^ a b "64-bit programming for Game Developers"
Retrieved April 18, 2023. ^ "Memory Limits for Windows Server Releases". Microsoft. Retrieved April 18, 2023. ^ "General Porting Guidelines". Programming Server Releases. Microsoft. Retrieved April 18, 2023. ^ "General Porting Guidelines". Programming Server Releases.
Guide for 64-bit Windows. Microsoft Docs. Retrieved April 18, 2023. ^ "Microsoft Docs. Retrieved April 18, 2023
5' launch in November". The Indian Express. August 31, 2020. Archived from the original on September 19, 2020. Retrieved September 14, 2020. ^ Cutress, Dr Ian. "Hot Chips 2020 Live Blog: Microsoft Xbox Series X System Architecture (6:00pm PT)". www.anandtech.com. Archived from the original on September 17, 2020. Retrieved September 14, 2020.
2020. ^ Hollister, Sean (November 12, 2021). "Steam Deck: Five big things we learned from Valve's developer summit". The Verge. Archived from the original on April 28, 2015. Retrieved September 4, 2013. ^ "An example file from the original on February 7, 2022. Retrieved November 12, 2021. ^ "ProcessorArchitecture Fields".
Linux 3.7.8 kernel source tree displaying the usage of the term x86 64". Archived from the original on September 23, 2005. Retrieved February 17, 2013. ^ US 6889312 ^ "Patent Cross License Agreement Between AMD and Intel". January 1, 2001. Archived from the original on June 21, 2007. Retrieved August 23, 2005. Retrieved February 17, 2018. ^ US 6889312 ^ US 6889312 ^ US 6889312 ^ "Patent Cross License Agreement Between AMD and Intel". January 1, 2001. Archived from the original on June 21, 2007. Retrieved February 17, 2018. ^ US 6889312 ^ US 6889
2009. ^ "AMD Intel Settlement Agreement". Archived from the original on July 7, 2017. Retrieved September 18, 2017. ^ Stephen Shankland and Jonathan E. Skillings (November 12, 2009). "Intel to pay AMD $1.25 billion in antitrust settlement". CNET. Archived from the original on November 8, 2012. Retrieved April 24, 2012. ^ Smith, Ryan
(November 12, 2009). "AMD and Intel Settle Their Differences: AMD Gets To Go Fabless". AnandTech. Archived from the original on May 13, 2010. AMD Developer Guides, Manuals & ISA Documents x86-64: Extending the x86 architecture to 64-bits - technical talk by the architect of AMD64 (video archive), and second talk by the same speaker (video
archive) AMD's "Enhanced Virus Protection" Intel tweaks EM64T for full AMD64 compatibility Analyst: Intel Reverse-Engineered AMD64 Early report of differences between Intel IA32e and AMD64 Porting to 64-bit GNU/Linux Systems, by Andreas Jaeger from GCC Summit 2003. An excellent paper explaining almost all practical aspects for a
transition from 32-bit to 64-bit. Intel 64 Architecture Intel Software Network: "64 bits" TurboIRC.COM tutorials, including examples of how to of enter protected and long mode the raw way from DOS Seven Steps of Migrating a Program to a 64-bit System Memory Limits for Windows Releases Retrieved from "2Computer architecture bit width "64-bit System Memory Limits for Windows Releases Retrieved from "2Computer architecture bit width "64-bit System Memory Limits for Windows Releases Retrieved from "3Computer architecture bit width "64-bit System Memory Limits for Windows Releases Retrieved from "3Computer architecture bit width "64-bit System Memory Limits for Windows Releases Retrieved from "3Computer architecture bit width "64-bit System Memory Limits for Windows Releases Retrieved from "3Computer architecture bit width "64-bit System Memory Limits for Windows Releases Retrieved from "3Computer architecture bit width "3Computer architecture bit w
bit" redirects here. For 64-bit images in computer graphics, see Deep color. This article by adding citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. Find sources: "64-bit computing" - news · newspapers · books · scholar · JSTOR (April 2023)
(Learn how and when to remove this message) Computer architecture bit widths Bit 14812161824263031323645486064128256512bit slicing Application 8163264 Binary floating-point precision 16 (\times4)256 (\times8) Decimal floating-point precision 3264128 vte Hex dump of the section table in a 64-bit Portable Executable Executab
File. A 64-bit word can be expressed as a sequence of 16 hexadecimal digits. In computer architecture, 64-bit integers, memory addresses, or other data units[a] are those that are 64 bits wide. Also, 64-bit central processing units (CPU) and arithmetic logic units (ALU) are those that are based on processor registers, address buses, or data buses of
that size. A computer that uses such a processor is a 64-bit computer. From the software perspective, 64-bit instruction sets support full 64-bit virtual memory addresses; x86-64 and AArch64, for example, support only 48 bits of virtual address.
with the remaining 16 bits of the virtual address required to be all zeros (000...) or all ones (111...), and several 64-bit instruction sets support fewer than 64 bits of physical memory address. The term 64-bit instruction sets support fewer than 64 bits of physical memory address.
architecture, buses, memory, and CPUs and, by extension, the software that runs on them. 64-bit CPUs have been used in supercomputers since the early 1990s. In 2003, 64-bit CPUs were introduced to the mainstream PC market in the
form of x86-64 processors and the PowerPC G5. A 64-bit register can hold any of 264 (over 18 quintillion or 1.8×1019) different values. The range of integer representations, the range is 0 through 18,446,744,073,709,551,615 (equal to 264 –
1) for representation as an (unsigned) binary number, and -9,223,372,036,854,775,808 (-263) through 9,223,372,036,854,775,807 (263 - 1) for representation as two's complement. Hence, a processor with 64-bit memory addresses can directly access 264 bytes (16 exabytes or EB) of byte-addressable memory. With no further qualification, a 64-bit
computer architecture generally has integer and addresses. However, a CPU might have external data buses or address buses with different sizes from the registers, even larger (the 32-bit Pentium had a 64-bit data buse, for instance).[1] This section does not
cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (April 2023) (Learn how and when to remove this message) Processor registers are typically divided into several groups: integer, floating-point, single instruction, multiple data (SIMD), control, and often
special registers for address arithmetic which may have various uses and names such as address, index, or base registers. In most processors, only integer or address-registers can be used to address data in memory; the other types of
registers cannot. The size of these registers therefore normally limits the amount of directly addressable memory, even if there are registers, such as floating-point registers, that are wider. Most high performance 32-bit MIPS architecture
(MIPS) CPUs) have integrated floating-point data and register format is 80 bits wide, while the general-purpose
registers are 32 bits wide. In contrast, the 64-bit Alpha family uses a 64-bit floating-point data and register format, and 64-bit integer register can store the memory address to any location in the computer's physical or virtual memory. Therefore, the total number of
addresses to memory is often determined by the width of these registers. The IBM System/360 of the 1960s was an early 32-bit computer; it had 32-bit integer registers, although it only used the low order 24 bits of a word for addresses, resulting in a 16 MiB (16 × 10242 bytes) address space. 32-bit superminicomputers, such as the DEC VAX, became
common in the 1970s, and 32-bit microprocessors, such as the Motorola 68000 family and the 32-bit members of the x86 family starting with the Intel 80386, appeared in the mid-1980s, making 32 bits something of a de facto consensus as a convenient register size. A 32-bit address register meant that 232 addresses, or 4 GB of random-access
memory (RAM), could be referenced. When these architectures were devised, 4 GB of memory was so far beyond the typical amounts (4 MiB) in installations, that this was considered to be enough headroom for addressing. 4.29 billion integers are
enough to assign unique references to most entities in applications like databases. Some supercomputer architectures of the 1970s and 1980s, such as the Cray-1,[2] used registers up to 64 bits wide, and supported 64-bit integer arithmetic, although they did not support 64-bit addressing. In the mid-1980s, Intel i860[3] development began
culminating in a 1989 release; the i860 had 32-bit integer arithmetic.[4] However, 32 bits remained the norm until the early 1990s, when the continual reductions in the cost of memory led to installations with amounts of RAM
approaching 4 GB, and the use of virtual memory spaces exceeding the 4 GB ceiling became desirable for handling certain types of problems. In response, MIPS and DEC developed 64-bit microprocessor architectures, initially for high-end workstation and server machines. By the mid-1990s, HAL Computer Systems, Sun Microsystems, IBM, Silicon
Graphics, and Hewlett-Packard had developed 64-bit architectures for their workstation and server systems. A notable exception to this trend were mainframes did not include 64-bit processors until 2000. During the 1990s, several low-cost 64-bit microprocessors
were used in consumer electronics and embedded applications. Notably, the Nintendo 64[5] and the PlayStation 2 had 64-bit microprocessors before their introduction in personal computers. High-end printers, network equipment, and industrial computers also used 64-bit microprocessors, such as the Quantum Effect Devices R5000.[6] 64-bit
computing started to trickle down to the personal computer desktop from 2003 onward, when some models in Apple's Macintosh lines switched to PowerPC 970 processors (termed G5 by Apple), and Advanced Micro Devices (AMD) released its first 64-bit x86-64 processors. Physical memory eventually caught up with 32-bit limits. In 2023, laptop
computers were commonly equipped with 16GB and servers starting from 64 GB of memory,[7] greatly exceeding the 4 GB address capacity of 32 bits. 1961 IBM delivers the IBM 7030 Stretch supercomputer, which uses 64-bit data words and 32- or 64-bit instruction words. 1974 Control Data Corporation launches the CDC Star-100 vector
supercomputer, which uses a 64-bit word architecture (prior CDC systems were based on a 60-bit architecture). International Computers Limited launches the ICL 2900 Series with 32-bit, 64-bit, and 128-bit two's complement integers; 64-bit architecture).
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architecture has survived through a succession of ICL and Fujitsu machines. The latest is the Fujitsu Supernova, which emulates the original environment on 64-bit word architecture and will form the basis for later Cray vector supercomputers.

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1983 Elxsi launches the Elxsi 6400 parallel minisupercomputer. The Elxsi architecture has 64-bit data registers but a 32-bit address space. 1989 Intel introduces the Elxsi 6400 parallel minisupercomputer. The Elxsi architecture has 64-bit data registers but a 32-bit address space. 1989 Intel introduces the Intel i860 reduced instruction set computer (RISC) processor. Marketed as a "64-Bit Microprocessor", it had essentially a 32-bit architecture, enhanced with a 3D graphics unit capable of
64-bit integer operations.[8] 1993 Atari introduces the Atari Jaguar video game console, which includes some 64-bit microprocessor, the R4000, which implements the MIPS III architecture, the third revision of its MIPS architecture.[10] The CPU is used in
SGI graphics workstations starting with the IRIS Crimson. Kendall Square Research deliver their first KSR1 supercomputer, based on a proprietary 64-bit RISC processor architecture which was born from the PRISM project.[11] 1994 Intel
announces plans for the 64-bit IA-64 architecture (jointly developed with Hewlett-Packard) as a successor to its 32-bit IA-32 processors. A 1998 to 1999 launch date was targeted. 1995 Sun launches a 64-bit SPARC processor, the UltraSPARC.[12] Fujitsu-owned HAL Computer Systems launches workstations based on a 64-bit CPU, HAL's
independently designed first-generation SPARC64. IBM releases the A10 and A30 microprocessors, the first 64-bit PowerPC AS processors. [13] IBM also releases a 64-bit AS/400 system upgrade, which can convert the operating system, database and applications.
variant of the MIPS R4000. HP releases the first implementation of its 64-bit PA-RISC 2.0 architecture, the PA-8000.[14] 1998 IBM releases the instruction set for the IA-64 architecture. AMD publicly discloses its set of 64-bit extensions to IA-32, called x86-64 (later
branded AMD64). 2000 IBM ships its first 64-bit z/Architecture and secondant of the 32-bit ESA/390 architecture, a descendant of the 32-bit System/360 architecture is a 64-bit version of the 32-bit ESA/390 architecture.
servers, sales fail to meet expectations. 2003 AMD introduces its Opteron and Athlon 64 processor lines, based on its AMD64 architecture which is the first x86-based 64-bit processor architecture which is the first x86-based 64-bit processor architecture which is the first x86-based on its AMD64 architecture which is the first x86-based on its AMD64 architecture which is the first x86-based on its AMD64 architecture which is the first x86-based on its AMD64 architecture.
Intel, reacting to the market success of AMD, admits it has been developing a clone of the AMD64 extensions of its Xeon and Pentium 4 processor families supporting the new 64-bit instruction set. VIA Technologies announces the Isaiah 64-bit
processor.[16] 2006 Sony, IBM, and Toshiba begin manufacturing the 64-bit Cell processor for use in the PlayStation 3, servers, workstations, and other appliances. Intel released Core 2 Duo as the first mainstream x86-64 processor for its mobile, desktop, and workstation line. Prior 64-bit extension processor lines were not widely available in the
consumer retail market (most of 64-bit Pentium 4/D were OEM), 64-bit Pentium 4/D were OEM), 64-bit Pentium 4/D were of due to poor yield issue (most of good yield wafers were targeted at server and mainframe while mainstream still remain 130 nm 32-bit processor line until 2006) and soon became low end after Core
2 debuted. AMD released their first 64-bit mobile processor and manufactured in 90 nm. 2011 ARM Holdings announced their Cortex-A53 and Cortex-A57 cores, their first cores based on their 64-bit architecture, on 30 October 2012.[18][19] 2013
Apple announces the iPhone 5S, with the world's first 64-bit processor in a smartphone, which uses their A7 ARMv8-A-based system-on-a-chip alongside the iPad Air and iPad Mini 2 which are the world's first 64-bit processor in a tablet. 2014 RISC-V was published[20]. Google announces the Nexus 9 tablet, the first Android device to run on the 64-bit
Tegra K1 chip. 2015 Apple announces the iPod Touch (6th generation), the first iPod Touch to use the 64-bit processor A8 ARMv8-A-based system-on-a-chip alongside the Apple TV. 2018 Apple announces the Apple Watch to use the 64-bit processor A8 ARMv8-A-based system-on-a-chip alongside the Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the 64-bit processor in an Apple TV. 2018 Apple announces the iPod Touch to use the iPod Touch t
processor S4 ARMv8-A-based system-on-a-chip. 2020 Synopsis announce the ARCv3 ISA, the first 64-bit implementation of the Unix operating system (later renamed Tru64 UNIX) for its systems based
on the Alpha architecture. 1994 Support for the R8000 processor is added by Silicon Graphics to the IRIX operating system in release 6.0. 1995 DEC releases OpenVMS 7.0, the first full 64-bit version of OpenVMS for Alpha. First 64-bit mode
is added by Silicon Graphics to the IRIX operating system in release 6.2. 1998 Sun releases Solaris 7, with full 64-bit UltraSPARC support. 2000 IBM releases z/OS, a 64-bit Linux on z Systems follows the CPU release almost immediately. 2001 Linux becomes the
first OS kernel to fully support x86-64 (on a simulator, as no x86-64 processors had been released yet).[24] 2001 Microsoft releases Windows XP 64-Bit Edition needed] 2003 Apple releases its Mac OS X 10.3 "Panther" operating system which adds
support for native 64-bit integer arithmetic on PowerPC 970 processors. [25] Several Linux distributions release with support for AMD64. FreeBSD releases with support for AMD64. FreeBSD releases with support for AMD64. FreeBSD releases with support for AMD64.
that it is developing x86-64 versions of Windows to replace it.[26] On January 31, Sun releases Solaris 10 with support for 64-bit command-line applications on machines with PowerPC 970 processors; later versions for Intel-based
Macs supported 64-bit command-line applications on Macs with EM64T processors. On April 30, Microsoft releases Windows XP Professional x64 Edition and Windows Server 2003 x64 Edition for AMD64 and EM64T processors. [27] 2006 Microsoft releases Windows XP Professional x64 Edition for AMD64 and EM64T processors that retains 32-bit
compatibility. In the 64-bit version, all Windows applications and components are 64-bit, although many also have their 32-bit versions included for compatibility with plug-ins.[citation needed] 2007 Apple releases Mac OS X 10.5 "Leopard", which fully supports 64-bit applications on machines with PowerPC 970 or EM64T processors.[citation needed]
2009 Microsoft releases Windows 7, which, like Windows Vista, includes a full 64-bit version for AMD64/Intel 64 processors; most new computers are loaded by default with a 64-bit version. Microsoft also releases Windows Server 2008 R2, which is the first 64-bit only server operating system. Apple releases Mac OS X 10.6, "Snow Leopard", which
ships with a 64-bit kernel for AMD64/Intel64 processors, although only certain recent models of Apple computers will run the 64-bit kernel by default on supported machines. Older machines that
are unable to run the 64-bit kernel run the 64-bit kernel, but, as with earlier releases, can still run 64-bit applications; Lion does not support machines with 32-bit processors. Nearly all applications; Lion does not support machines with 32-bit processors. Nearly all applications bundled with Mac OS X 10.7 are now also 64-bit, including iTunes.[citation needed] 2012 Microsoft releases Windows 8 which supports UEFI Class 3
(UEFI without CSM) and Secure Boot.[28] Apple releases OS X Mountain Lion, which makes the 64-bit kernel that supports 64-bit kernel that supports 64-bit kernel that supports 64-bit applications.[citation needed] 2014
Google releases Android Lollipop, the first version of the Android operating system with support for 64-bit processors. [citation needed] 2017 Apple releases iOS 11, supporting only machines with AArch64 processors. [citation needed] 2018 Apple
releases watchOS 5, the first watchOS version to bring the 64-bit support. [citation needed] 2019 Apple releases macOS 10.15 "Catalina", dropping support for 32-bit Intel applications. [citation needed] 2021 Microsoft releases Windows 11 on October 5, which only supports 64-bit systems, dropping support for IA-32 and AArch32 systems. [citation needed] 2021 Microsoft releases Windows 11 on October 5, which only supports 64-bit systems, dropping support for IA-32 and AArch32 systems. [citation needed] 2021 Microsoft releases Windows 11 on October 5, which only support for IA-32 and AArch32 systems. [citation needed] 2021 Microsoft releases Windows 11 on October 5, which only support for IA-32 and AArch32 systems.
needed] 2022 Google releases the Pixel 7, which drops support for 32-bit applications. Apple Watch Series 4 or newer, Apple Watch SE (1st generation) or newer and the newly introduced Apple Watch Ultra), dropping
support for Apple Watch Series 3 as the final Apple Watch model with 32-bit processor.[citation needed] 2024 Microsoft releases Windows 11 2024 Update, ARM versions of which drop support for 32-bit ARM applications. In principle, a 64-bit microprocessor can address 16 EB (16 × 10246 = 264 = 18,446,744,073,709,551,616 bytes) of memory.
However, not all instruction sets, and not all processors implementing those instruction sets, support a full 64-bit virtual or physical address space. The x86-64 architecture (as of March 2024[update]) allows 48 bits for virtual memory sizes of 256 TB
(256 × 10244 bytes) and 4 PB (4 × 10245 bytes), respectively. A PC cannot currently contain 4 petabytes of memory clusters, and other uses of physical address space that might approach this in the foreseeable future. Thus the 52-bit physical address
provides ample room for expansion while not incurring the cost of implementing full 64-bit physical addresses. Similarly, the 48-bit virtual addresses. Similarly, the 48-bit virtual addresses. The Power ISA
v3.0 allows 64 bits for an effective address, mapped to a segmented address with between 65 and 78 bits for physical memory, and, for any given processor, up to 60 bits for physical memory, and, for any given processor, up to 60 bits for physical memory, and, for any given processor, between 40 and 56 bits for physical memory.
[32] The ARM AArch64 Virtual Memory System Architecture allows from 48 to 56 bits for virtual memory and, for any given processor, from 32 to 56 bits for physical memory. [33] The DEC Alpha specification requires minimum of 43 bits of virtual memory and for any given processor, from 32 to 56 bits for physical memory.
unsupported bits are zero (to support compatibility on future processors). Alpha 21064 supported 43 bits of virtual memory address space (8 TB) and 40 bits of physical memory address space (1 TB). Alpha 21264 supported
user-configurable 43 or 48 bits of virtual memory address space (8 TB or 256 TB) and 44 bits of physical memory address space (16 TB). A change from a 32-bit to a 64-bit architecture is a fundamental alteration, as most operating systems must be extensively modified to take advantage of the new architecture, because that software has to manage
the actual memory addressing hardware. [34] Other software must also be ported to use the new abilities; older 32-bit instruction set, so that processors that support the 64-bit instruction set can also run code for the 32-bit instruction set, or through
software emulation, or by the actual implementation of a 32-bit processor core within the 64-bit processor core within the 64-bit applications. The operating systems for those 64-bit architectures generally support both 32-bit and 64-bit applications. [35] One significant
exception to this is the IBM AS/400, software for which is compiled into a virtual instruction set architecture (ISA) called Technology Independent Machine Interface (TIMI); TIMI code is then translated to native machine code by low-level software before being executed. The translation software is all that must be rewritten to move the full OS and all
software to a new platform, as when IBM transitioned the native instruction set for AS/400 from the older 32/48-bit PowerPC, so this transition was even bigger than moving a given instruction set from 32 to 64 bits. On 64-bit
hardware with x86-64 architecture (AMD64), most 32-bit operating systems and applications can run with no compatibility issues. While the larger address space of 64-bit architectures makes working with large data sets in applications such as digital video, scientific computing, and large databases easier, there has been considerable debate on
whether they or their 32-bit compatibility modes will be faster than comparably priced 32-bit systems for other tasks. A compiled Java program can run on a 32- or 64-bit Java virtual machine with no modification. The lengths and precision of all the built-in types, such as char, short, int, long, float, and double, and the types that can be used as array
indices, are specified by the standard and are not dependent on the underlying architecture. Java programs that run on a 64-bit Java virtual machine have access to a larger address space. [36] Speed is not the only factor to consider in comparing 32-bit and 64-bit processors. Applications such as multi-tasking, stress testing, and clustering - for high
performance computing (HPC) - may be more suited to a 64-bit architecture when deployed appropriately. For this reason, 64-bit processor performs best with 64-bit software. A 64-bit processor may have backward compatibility, allowing it
to run 32-bit application software for the 32-bit version of its instruction set, and may also support running 32-bit operating systems for the 32-bit architectures are no better than 32-bit architectures unless the computer has
more than 4 GB of random-access memory. [37] This is not entirely true: Some operating systems and certain hardware configurations limit the physical memory space to 3 GB on IA-32 systems, due to much of the 3-4 GB region being reserved for hardware addressing; see 3 GB barrier; 64-bit architectures can address far more than 4 GB. However,
IA-32 processors from the Pentium Pro onward allow a 36-bit physical memory address space, using Physical Address Extension (PAE), which gives a 64 GB physical memory, even on IA-32 processors.
However, drivers and other kernel mode software, more so older versions, may be incompatible with PAE; this has been disputed [39]). Some operating systems reserve portions of process address
 space for OS use, effectively reducing the total address space available for mapping memory for user programs. For instance, 32-bit Windows reserves 1 or 2 GB (depending on the settings) of the address space available for user mode. This limit is much higher on 64-
bit operating systems. Memory-mapped files are becoming more difficult to implement in 32-bit architectures as files of over 4 GB become more common; such large files cannot be memory-mapped easily to 32-bit architectures, as only part of the file can be mapped into the address space at a time, and to access such a file by memory mapping, the
parts mapped must be swapped into and out of the address space as needed. This is a problem, as memory mapping, if properly implemented by the OS, is one of the most efficient disk-to-memory methods. Some 64-bit programs, such as encoders, decoders and encryption software, can benefit greatly from 64-bit registers, [citation needed] while the
performance of other programs, such as 3D graphics-oriented ones, remains unaffected when switching from a 32-bit to a 64-bit architectures, such as x86-64 and AArch64, support more general-purpose registers than their 32-bit counterparts (although this is not due specifically to the word length). This
 leads to a significant speed increase for tight loops since the processor does not have to fetch data from the cache or main memory if the data can fit in the available registers. Example in C: int a, b, c, d, e; for (a = 0; a < 100; a++) { b = a; c = b; d = c; e = d; } This code first creates 5 values: a, b, c, d and e; and then puts them in a loop. During the
loop, this code changes the value of a, the value of a to the value of a, the value of a to the value 
to be able to process variables d and e also; this is a process that takes many CPU cycles. A processor that can hold all values and variables in registers can loop through them with no need to move data between registers are contingent on
the compiler. The main disadvantage of 64-bit architectures is that, relative to 32-bit architectures, the same data occupies more space in memory (due to longer pointers and possibly other types, and alignment padding). This increases the memory requirements of a given process and can have implications for efficient processor cache use.
Maintaining a partial 32-bit model is one way to handle this, and is in general reasonably effective. For example, the z/OS operating system takes this approach, requiring program code to reside in 31-bit address spaces (the high order bit is not used in address calculation on the underlying hardware platform) while data objects can optionally reside
in 64-bit regions. Not all such applications require a large address space or manipulate 64-bit data items, so these applications do not benefit from these features. x86-based 64-bit systems sometimes lack equivalents of software that is written for 32-bit architectures. The most severe problem in Microsoft Windows is incompatible device drivers for
obsolete hardware. Most 32-bit application software can run on a 64-bit operating system in a compatibility mode, e.g., Microsoft WoW64 Technology for IA-64 and AMD64. The 64-bit Win32 subsystem code (often
devices whose actual hardware function is emulated in user mode software, like Winprinters). Because 64-bit drivers for most devices were unavailable until early 2007 (Vista x64), using a 64-bit version of Windows was considered and the
use of more than 4 GB of RAM increased. Most manufacturers started to provide both 32-bit drivers for new devices, so unavailability of 64-bit drivers ceased to be a problem. 64-bit drivers ceased to be a problem with
open-source drivers, as 32-bit ones could be modified for 64-bit use. Support for hardware made before early 2007, was problematic for open-source platforms, [citation needed] due to the relatively small number of users. 64-bit users are forced to
install a virtual machine of a 16- or 32-bit operating system to run 16-bit applications or use one of the alternatives for NTVDM.[41] Mac OS X 10.5 "Leopard" had both 32- and 64-bit kernels, and, on most
Macs, used the 32-bit kernel even on 64-bit processors. This allowed those Macs to support 64-bit processors while still supporting 32-bit device drivers; although not 64-bit drivers and OS X 10.8 "Mountain Lion" and later macOS
releases only have a 64-bit kernel. On systems with 64-bit processors, both the 32- and 64-bit wersions of libraries that 32-bit applications would use, so 32-bit user-mode software for macOS will run on those systems. The 32-bit
versions of libraries have been removed by Apple in macOS Catalina (10.15). Linux and most other Unix-like operating systems, and the C and C++ toolchains for those platforms are open-source software, written in C and C++, so that if they are 64-bit-safe
they can be compiled into 64-bit versions. This source-based distribution model, with an emphasis on frequent releases, makes availability of application software for those operating systems less of an issue. In 32-bit programs, pointers and data types such as integers generally have the same length. This is not necessarily true on 64-bit machines.[42]
[43][44] Mixing data types in programming languages such as C++ and Objective-C may thus work on 32-bit implementations but not on 64-bit implementations. In many programming environments for C and C-derived languages on 64-bit implementations. In many programming environments for C and C-derived languages on 64-bit implementations.
64 bits wide. These are described as having an LP64 data model, which is an abbreviation of "Long, Pointer, 64".[45][46] other models are the ILP64 data model in which all three data types are 64 bits wide, [47][46] and even the SILP64 model where short integers are also 64 bits wide.
relatively minor and straightforward, and many well-written programs can simply be recompiled for the new environment with no changes. Another alternative is the LLP64 model, which maintains compatibility with 32-bit code by leaving both int and long as 32-bit. [50][46] LL refers to the long long integer type, which is at least 64 bits on all
platforms, including 32-bit environments. There are also systems with 64-bit processors using an ILP32 data model, with the addition of 64-bit long long integers; this is also used on many platforms with 32-bit processors. This model reduces code size and the size of data structures containing pointers, at the cost of a much smaller address space, a
good choice for some embedded systems. For instruction sets such as x86 and ARM in which the 64-bit version of the instruction set has more registers without the space penalty. It is common in 64-bit RISC machines, [citation needed] explored in x86 as x32 ABI, and has
recently been used in the Apple Watch Series 4 and 5.[51][52] 64-bit data models Datamodel shortint int longing Pointer, size t Sample operating systems; MIPS N32 ABI. LLP64 16 32 32 64 64 Microsoft Windows (x86-64, IA-64, and ARM64) using Visual C++; and MinGW
HP-UX, Linux, macOS, BSD, and IBM z/OS). Microsoft Windows uses an LLP64 model is that storing a pointer to a long will "work" in LP64. In the LLP64 model, the reverse is true. These are not problems which affect fully standard-compliant code, but
code is often written with implicit assumptions about the widths of data types. C code should prefer (u)intptr t instead of long when casting pointers into integer objects. A programming model is a choice made to suit a given compiler, and several can coexist on the same OS. However, the programming model chosen as the primary model for the OS
application programming interface (API) typically dominates. Another consideration is the data model used for device drivers use pointers heavily to
manipulate data, and in some cases have to load pointers of a certain size into the hardware they support for direct memory access (DMA). As an example, a driver for a 32-bit PCI device asking the device to DMA data into upper areas of a 64-bit machine's memory could not satisfy requests from the operating system to load data from the device to
memory above the 4 gigabyte barrier, because the pointers for those addresses would not fit into the DMA registers of the device. This problem is solved by having the OS take the memory management unit (IOMMU). This section
does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (April 2023) (Learn how and when to remove this message) As of August 2023[update], 64-bit architectures for which processors are being manufactured include: The 64-bit extension created by
newer Celeron, Pentium, and Xeon processors Intel's K1OM architecture, a variant of Intel 64 with no CMOV, MMX, and SSE instructions, used in first-generation Xeon Phi (Knights Corner) coprocessors, binary incompatible with x86-64 programs VIA Technologies' 64-bit extensions, used in the VIA Nano processors ARM Holdings' AArch64
architecture IBM's PowerPC/Power ISA: IBM's PowerPC/Power ISA: IBM's Power10 processor and predecessors, and the IBM A2 processors IBM's z/Architecture, a 64-bit version of the ESA/390 architecture, used in IBM's IBM Z mainframes: IBM Telum II processor and predecessors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors and predecessors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors and predecessors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors and predecessors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 and S7 processors Hitachi AP8000E RISC-V SPARC V9 architecture; Oracle's M8 archit
no performance penalty.[citation needed] This kind of support is commonly called bi-arch support or more generally multi-arch support. Computer memory ^ such as floating-point numbers. ^ Pentium Processor User's Manual Volume 1: Pentium Processor Data Book (PDF). Intel. 1993. ^ "Cray-1 Computer System Hardware Reference Manual Volume 1: Pentium Processor Data Book (PDF).
popular Nintendo 64<sup>™</sup> video game and advanced laser printers such as the recently announced, award-winning Hewlett-Packard LaserJet 4000 printer family. ^ MIPS R5000 Microprocessor Technical Backgrounder (PDF), MIPS Technologies, Inc, retrieved 2024-08-19 ^ "DDR5 | DRAM". Samsung Semiconductor Global. Retrieved 2025-01-19. ^
 'i860 64-Bit Microprocessor". Intel. 1989. Archived from the original on 19 March 2011. Retrieved 30 November 2010. ^ "Atari Jaguar History". AtariAge. ^ Joe Heinrich (1994). "Alpha AXP Architecture". Digital Technical Journal. 4 (4). Digital
Equipment Corporation. ^ Gwennap, Linley (3 October 1994). "UltraSparc Unleashes SPARC Performance". Microprocessor Report. 8 (13). MicroDesign Resources. ^ Bishop, J. W.; et al. (July 1996). "PowerPC AS A10 64-bit RISC microprocessor". IBM Journal of Research and Development. 40 (4). IBM Corporation: 495–505. doi:10.1147/rd.404.0495.
 ^ Gwennap, Linley (14 November 1994). "PA-8000 Combines Complexity and Speed". Microprocessor Report. 8 (15). MicroDesign Resources. ^ F. P. O'Connell; S. W. White (November 2000). "POWER3: The next generation of PowerPC processors". IBM Journal of Research and Development. 44 (6). IBM Corporation: 873-884.
doi:10.1147/rd.446.0873. ^ "VIA Unveils Details of Next-Generation Isaiah Processor Core" (Press release). VIA Technology Preview" (PDF). October 31, 2011. Archived from the original (PDF) on November 11, 2011. Retrieved November 15, 2012
Launches Cortex-A50 Series, the World's Most Energy-Efficient 64-bit Processors" (Press release). ARM Holdings. Retrieved 2012-10-31. ARM Keynote: ARM Cortex-A53 and ARM Cortex-A53 and ARM Cortex-A57 64bit ARMv8 processors launched". ARMdevices.net. 2012-10-31. ARMdevices.net. 2012-10-31. ARM Keynote: ARM Cortex-A53 and ARM Cortex-A57 64bit ARMv8 processors launched". ARMdevices.net. 2012-10-31. ARMdevices.net. 2012-10-31. ARM Cortex-A57 64bit ARMv8 processors launched". ARMdevices.net. 2012-10-31. ARM Cortex-A50 64bit ARMv8 processors launched". ARMdevices.net. 2012-10-31. ARM Cortex-A50 64bit ARMv8 processors launched". ARMdevices.net. 2012-10-31. ARMdevices.net. 
The Case For RISC-V (PDF). EECS Department, University of California, Berkeley. UCB/EECS-2014-146. ^ "Synopsys Introduces New 64-bit ARC Processor IP". Archived from the original on 26 November 2010. Retrieved 2010-11-
19. ^ Jon "maddog" Hall (Jun 1, 2000). "My Life and Free Software". Linux Journal. ^ Andi Kleen. Porting Linux to x86-64 (PDF). Ottawa Linux Symposium 2001. Status: The kernel boots and work on simulator and is used for porting of userland and running programs ^ a b John Siracusa (September 2009). "Mac
OS X 10.6 Snow Leopard: the Ars Technica review". Ars Technica p. 5. Archived from the original on 9 October 2009. Retrieved 2009-06. ^ Joris Evers (5 January 2005). "Microsoft Raises the Speed Limit with the
Availability of 64-Bit Editions of Windows XP Professional" (PDF). Advanced Micro Devices. March 2024. p. 127. "Intel 64 and IA-32" (PDF). Advanced Micro Devices. March 2024. p. 127. "Intel 64 and IA-32" (PDF).
Architectures Software Developer's Manual Volume 3A: System Programming Guide, Part 1" (PDF). Intel. September 2015. p. 4-2. ^ "Power ISA Version 3.0". IBM. November 16, 2016. p. 4-75. Archived from the original (PDF) on April 22, 2020. ^ "ARM
Architecture Reference Manual for A-profile architecture". 30 November 2024. section D8.1.6 "Implemented physical address size", section D8.1.8 "Supported virtual address size", sectio
April 2009. Archived from the original on 5 April 2009. Retrieved 2009-04-05. Trequently Asked Questions About the Java HotSpot VM". Oracle. Retrieved 2024-12-13. The description of the differences between 32-bit versions of Windows Vista and 64-bit versions of Windows Vista. Archived from the original on 2011-10-15. Retrieved 2011-10-14.
 ^{\circ} Mark Russinovich (2008-07-21). "Pushing the Limits of Windows: Physical Memory". Archived from the original on 2017-04-07. Retrieved 2017-03-09. ^{\circ} Chappell, Geoff (2009-01-27). "Licensed Memory in 32-Bit Windows Vista". geoffchappell.com. WP:SPS. Retrieved 9 March 2017. ^{\circ} "Inside Native Applications". Technet.microsoft.com. 2006-11-01
Archived from the original on 23 October 2010. Retrieved 2010-11-19. ^ Lincoln Spector (August 12, 2013). "Run an old program on a new PC". ^ Peter Seebach (2006). "Exploring 64-bit development on POWER5: How portable is your code, really?". IBM. ^ Henry Spencer. "The Ten Commandments for C Programmers". ^ "The Story of Thud and
Blunder". Datacenterworks.com. Retrieved 2010-11-19. ^ "ILP32 and LP64 data models and data type sizes". z/OS XL C/C++ Programming Guide. ^ a b c "64-Bit Programming Models". Retrieved 2010-11-19. ^ "Using the ILP64 Interface vs. LP64 Interface". Intel. Retrieved Jun 24, 2020. ^ a b "Cray C/C++ Reference Manual". August 1998. Table 9
1. Cray Research systems data type mapping. Archived from the original on October 16, 2013. A b "Cray C and C++ Reference Manual (8.7) S-2179". Retrieved Jun 24, 2020. Take the original on October 15, 2013. A b "Cray C and C++ Reference Manual (8.7) S-2179". Retrieved Jun 24, 2020. Take the original on October 15, 2013. A chived from the original on October 16, 2013. Take the original original
the original on December 30, 2018. Retrieved October 9, 2018. ^ "Apple devices in 2018". woachk, security researcher. October 6, 2018. 64-bit Errors in Real Programs". Archived from the original on September 23, 2021. Kilgard, Mark J. "Is your X code
ready for 64-bit?". Archived from the original on June 3, 2001. Retrieved September 26, 2012. Lessons on development of 64-bit C/C++ applications at the Wayback Machine (archived April 14, 2021) 64-Bit Programming Models: Why LP64? AMD64 (EM64T) architecture Retrieved from "3Computer architecture bit width "16-bit" redirects here. For
the color encoding, see 16-bit color. For the video gaming era, see 16-bit era. For other uses, see 16-bit (disambiguation). This article by adding citations to reliable sources. Unsourced material may be challenged and removed. Find sources: "16-bit computing" - news
newspapers · books · scholar · JSTOR (March 2023) (Learn how and when to remove this message) Computer architecture bit widths Bit 14812161824263031323645486064128256512bit slicing Application 8163264 Binary floating-point precision 16 (×½)2432 (×1)4064 (×2)80128 (×4)256 (×8) Decimal floating-point precision 3264128 vte In
computer architecture, 16-bit integers, memory addresses, or other data units are those that are based on registers, address buses, or data buses of that size. 16-bit microcomputers are microcomputers that use 16-bit
microprocessors. A 16-bit register can store 216 different values. The range of integer values that can be stored in 16 bits depends on the integer representation as an (unsigned) binary number, and -32,768 (-1 × 215) through 32,767 (215).
- 1) for representation as two's complement. Since 216 is 65,536, a processor with 16-bit memory addresses can directly access 64 KB (65,536 bytes) of byte-addressable memory. If a system uses segmentation with 16-bit segment offsets, more can be accessed. As of 2025, 16-bit microcontrollers cost well under a dollar (similar to close in price
legacy 8-bit[1][2]); the cheapest 16-bit microcontrollers cost less than other types[3] including any 8-bit (and are more powerful, and easier to program generally), making 8-bit legacy, i.e. not worth it for new applications; 32-bit microcontrollers are also well under half a dollar, cheaper than most 16-bit, with few exceptions, then close to cheapest 16
bit. Digital Equipment Corporation PDP-11, a popular 16-bit minicomputer during the 1970s The MIT Whirlwind (c. 1951)[4][5] was quite possibly the first-ever 16-bit computer. It was an unusual word size for the era; most systems used six-bit character code and used a word length of some multiple of 6-bits. This changed with the effort to introduce and used six-bit character code and used a word length of some multiple of 6-bits.
ASCII, which used a 7-bit code and naturally led to the use of an 8-bit multiple which could store a single ASCII character or two binary-coded decimal digits. The 16-bit word length thus became more common in the 1960s, especially on minicomputer systems. Early 16-bit computers (c. 1965–70) include the IBM 1130,[6] the HP 2100,[7] the Data
General Nova,[8] and the DEC PDP-11.[9] Early 16-bit microprocessors, often modeled on one of the mini platforms, began to appear in the 1970s. Examples (c. 1973-76) include the five-chip Western Digital MCP-1600 (1975), and the five-chip Nec μCOM-16 (1974),[11][10] the two-chip Nec μCOM-16 (1974),[11][10] the three-chip Western Digital MCP-1600 (1975), and the five-chip Nec μCOM-16 (1974),[11][10] the three-chip Western Digital MCP-1600 (1975), and the five-chip Nec μCOM-16 (1974),[11][10] the three-chip Western Digital MCP-1600 (1975), and the five-chip Nec μCOM-16 (1974),[11][10] the three-chip Nec μCOM-16 (1974),[1
Toshiba T-3412 (1976).[10] Early single-chip 16-bit microprocessors (c. 1975, Texas Instruments TMS9900 (1975), Texas Instruments TMS9900 (197
80286, the WDC 65C816, and the Zilog Z8000. The Intel 8088 was binary compatible with the Intel 8086, and was 16-bit quantities, even though its external bus was 8 bits wide. 16-bit processors have been almost entirely supplanted in the personal computer
arithmetic is performed using two 16-bit operations, and this leads to some descriptions of the system as 16-bit, or "16/32". Such solutions have a long history in the computer field, with various designs performing math even one bit at a time. A
common example is the Data General Nova, which was a 16-bit design that performed 16-bit math as a series of four 4-bit operations. 4-bits was the word size of a widely available single-chip ALU and thus allowed for inexpensive implementation. Using the definition being applied to the 68000, the Nova would be a 4-bit computer, or 4/16. Not long
after the introduction of the Nova, a second version was introduced, the SuperNova, which included four of the 4-bit ALUs running in parallel to perform math 16 bits at a time and therefore offer higher performance. This was invisible to the user and the programs, which always used 16-bit instructions and data. In a similar fashion, later 68000-family
members, starting with the Motorola 68020, had 32-bit ALUs. One may also see references to systems being, or not being, 16-bit based on some other measure. One common one is when the address space is not the same size of bits as the internal registers. Most 8-bit CPUs of the 1970s fall into this category; the MOS 6502, Intel 8080, Zilog Z80 and and a size of bits as the internal registers.
most others had 16-bit address space which provided 64 KB of address space. This also meant address space which provided 64 KB of address space which provided 64 KB of address space which provided 64 KB of address space. This also meant address space which provided 64 KB of address space which pro
1980s, although often reversed, as memory costs of the era made a machine with 32-bit addressing, 2 or 4 GB, a practical impossibility. For example, the 68000 exposed only 24 bits of addressing on the DIP, limiting it to a still huge (for the era) 16 MB.[14] A similar analysis applies to Intel's 80286 CPU replacement, called the 386SX, which is a 32-bit
processor with 32-bit ALU and internal 32-bit data paths with a 16-bit external bus and 24-bit addressing of the processor it replaced. In the context of IBM PC compatible and Wintel platforms, a 16-bit application is any software written for MS-DOS, OS/2 1.x or early versions of Microsoft Windows which originally ran on the 16-bit Intel 8088 and
Intel 80286 microprocessors. Such applications used a 20-bit or 24-bit segment or selector-offset addresses. Programs containing more than 216 bytes (65,536 bytes) of instructions and data therefore required special instructions
to switch between their 64-kilobyte segments, increasing the complexity of programming 16-bit applications. This list is incomplete; you can help by adding missing items. (November 2021) Angstrem 1801 series CPU Data General Nova Eclipse Digital Equipment Corporation PDP-11 (for LSI-11, see Western Digital, below) DEC J-11 DEC T-11 EnSilications.
eSi-1600 Fairchild Semiconductor 9440 MICROFLAME Ferranti F200-L General Instrument CP1600 Hewlett-Packard HP 21xx/2000/1000/98xx/BPC HP 3000 Honeywell Level 6/DPS 6 IBM 1130/1800 System/7 Series/1 System/36 Infineon XE166 family C166/C167 family XC2000 Intel Intel 8086/Intel 8088 Intel
80186/Intel 80188 Intel 80286 Intel MCS-96 Lockheed MAC-16 MIL-STD-1750A Motorola 68HC12 Motorola 68HC12 Motorola 68HC16 National Semiconductor IMP-16 PACE/INS8900 NEC µCOM-16 NEC V20 and V30 Panafacom MN1610 Renesas Renesas M16C [jp] (16-bit registers, 24-bit address space) Ricoh Ricoh FA22 (WDC 65816 clone used in SNES)
Texas Instruments Texas Instruments Texas Instruments TMS9900 TI MSP430 Toshiba T-3412 Western Design Center WDC 65816/65802 Western Digital MCP-1600 used in the WD16 Xerox Alto Zilog Zilog Z280 Microprocessor § 16-bit designs Influence of the IBM PC on the personal computer
market § Before the IBM PC's introduction 74181 (key component of some early 16-bit and other CPUs) Audio bit depth - as 16-bit is the most common bit depth used, e.g. on CD audio. ^ "The Amazing $1 Microcontroller". ^ "16-bit
Microcontrollers - MCU". ^ "Year 1951". Computer History Museum. (see also "Year 1943".). ^ Digital Press, Digital at Work Archived 2013-07-02 at the Wayback Machine, Pearson, 1992, ISBN 1-55558-092-0, pp. 4, 23. ^ "The IBM 1130 computing system". IBM Archived from the original on March 18, 2005. ^ "HP 2116". Computer History Museum.
Museum. ^ "Data General Nova minicomputer". Computer History Museum. Archived from the original on 2013-05-17. Retrieved 2012-06-11. ^ Pearson, Jamie Parker (September 1992). Digital at work: snapshots from the first thirty-five years. Digital Press. pp. 58-61. ISBN 978-1-55558-092-6. ^ a b c d e Belzer, Jack; Holzman, Albert G.; Kent, Allen
(1978). Encyclopedia of Computer Science and Technology. Vol. 10 - Linear and Matrix Algebra to Microorganisms: Computer-Assisted Identification. CRC Press. p. 402. ISBN 9780824722609. ^ "1970s: Development and evolution of microprocessors" (PDF). Semiconductor History Museum of Japan. Archived from the original (PDF) on 2019-06-27.
Retrieved 2019-06-27. "16-bit Microprocessors". CPU Museum. Retrieved 5 October 2010. "History". PFU. Retrieved 5 October 2010. "Motorola M68000 Family, Programmer's Reference Manual (PDF). Motorola M68000 Family, Programmer's Reference Manual (PDF).
(link count transclusion count sorted list) · See help page for transcluding these entries Showing 50 items. View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)ASCII (links | edit) Atari ST (li
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a type of proprietary software that is initially shared by the owner for trial use at little or no cost.[1] Often the software developer.[2] Shareware is often offered as a download from a website. Shareware differs from freeware, which is fully-featured
software distributed at no cost to the user but without source code being made available; and free and open-source software, in which the source code is freely available for anyone to inspect and alter. There are many types of shareware and, while they may not require an initial up-front payment, many are intended to generate revenue in one way or
another. Some limit use to personal non-commercial purposes only, with purchase of a license required for use in a business enterprise. The software itself may be time-limited, or it may remind the user that payment would be appreciated. Trialware or demoware is a program that limits the time that it can be effectively used, commonly via a built-in
time limit, number of uses, or only allowing progression up to a certain point (e.g. in video games, see Game demo).[3] The user can try out the fully featured progression up to a certain point trialware reverts to either a reduced-functionality (freemium, nagware, or crippleware) or non-functional mode, unless the user purchases a
full version.[4] Trialware has become normalized for online Software as a Service (SaaS).[citation needed] WinRAR is a notable example of an unlimited trialware is to give potential users the opportunity to try out the program to judge
its usefulness before purchasing a license. According to industry research firm Softletter, 66% of online companies surveyed had free-trial-to-paying-customer convert them into paying customers. Main article: Freemium Freemium works by
offering a product or service free of charge (typically digital offerings such as software, content, games, web services or other) while charging a premium for advanced features disabled until a feature-limited version may be given away for free, with advanced features disabled until a feature-limited version may be given away for free, with advanced features disabled until a feature-limited version may be given away for free, with advanced features disabled until a feature-limited version may be given away for free, with advanced features disabled until a feature-limited version may be given away for free, with advanced features disabled until a feature-limited version may be given away for free, with advanced features disabled until a feature-limited version may be given away for free, with advanced features disabled until a feature-limited version may be given away for free, with advanced feature feature-limited version may be given away for free, with advanced feature-limited version may be given away for free, with advanced feature-limited version may be given away for free features disabled until a feature-limited version may be given away for free features disabled until a feature-limited version may be given away for free features disabled until a feature-limited version may be given away for free features away for free features disabled until a feature-limited version may be given away for free features away for feature away for free feat
license fee is paid. The word freemium combines the two aspects of the business model: "free" and "premium".[5] It has become a popular model especially in the antivirus industry. Main article: Adware Adware, short for "advertising-supported software", is any software package which automatically renders advertisements in order to generate
revenue for its author. Shareware is often packaged with adware to lower the shareware fees or eliminate the need to charge users a fee. The advertisements may take the form of a banner on an application window. The functions may be designed to analyze which websites the user visits and to present advertising pertinent to the types of goods or
services featured there. The term is sometimes used to refer to software that displays unwanted advertisements, which typically are more intrusive and may appear as pop-ups, as is the case in most ad-oriented spyware. [6] During the installation of the intended software, the user is presented with a requirement to agree to the terms of click through
an end-user license agreement or similar licensing which governs the installation of the software.[7] Main article: Crippleware has vital features of the program, such as printing or the ability to save files, disabled or unwanted features of the program, such as printing or the ability to save files, disabled or unwanted features of the program, such as printing or the ability to save files, disabled or unwanted features like watermarks on screencasting and video editing software.[8] until the user buys the software.
allows users to take a close look at the features of a program without being able to use it to generate output. The distinction between freemium and crippleware is that an unlicensed freemium program has useful functionality, while crippleware is that an unlicensed freemium program has useful functionality, while crippleware is that an unlicensed freemium program has useful functionality, while crippleware is that an unlicensed freemium program has useful functionality.
licensing model that supplies fully operational unrestricted software to the user and requests an optional donation may also be stipulated by the author, or it may be left to the discretion of the user, based on individual perceptions of the
software's value. Since donationware comes fully operational (i.e. not crippleware) with payment optional, it is a type of freeware. In some cases, there is a delay to start the project. This nag feature and/or delayed start is often removed in an update once the user has
donated to (paid for) the software. Nagware (also known as begware, annoyware or a nagscreen) is a pejorative term for shareware that persistently reminds the user to purchase a license.[10] It usually does this by popping up a message when the user starts the program, or intermittently while the user is using the application. These messages can
appear as windows obscuring part of the screen, or as message boxes that can quickly be closed. Some nagware keeps the message up for a certain time period, forcing the user to wait to continue to use the program. Unlicensed programs that support printing may superimpose a watermark on the printed output, typically stating that the output was
produced by an unlicensed copy. Some titles display a dialog box with payment information and a message that paying will remove the notice, which is usually displayed either upon startup or after an interval while the application is running. These notices are designed to annoy the user into paying. Postcardware, also called just cardware, is a style of
beerware. The concept was first used by Aaron Giles, author of JPEGView.[11] Another well-known piece of postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery, whose author collects postcardware is the roguelike game Ancient Domains of Mystery and Domains Domai
postcardware.[12] Caledos Automatic Wallpaper Changer is a "still alive" project cardware for a long time.[13] An example for emailware is the video game Jump 'n Bump.[14] Another popular postcardware company is the Laravel
package developers from Spatie, which has released over 200 open-source packages to the Laravel framework, which are postcardware licensed, and all shown at their website.[15] In 1982, Andrew Fluegelman created a program for the IBM PC called PC-Talk, a telecommunications program, and used the term freeware; he described it "as an
experiment in economics more than altruism".[16] About the same time, Jim "Button" Knopf released PC-File, a database program, calling it user-supported software. [17] Not much later, Bob Wallace produced PC-Write, a word processor, and called it shareware. Appearing in an episode of Horizon titled Psychedelic Science originally broadcast 5
 April 1998. Bob Wallace said the idea for shareware came to him "to some extent as a result of my psychedelic experience".[18] Fluegelman said that his experience as a book publisher and author discouraged him from finding a traditional software publisher. KQED pleage drives inspired his distribution method, as well as his not knowing now to
implement copy protection.[19] In 1983 Jerry Pournelle wrote of "an increasingly popular variant" of free software "that has no name, but works thus: 'If you like this, send me (the author) some money. I prefer cash.'"[20] In 1984, Softalk-PC magazine had a column, The Public Library, about such software. Public domain is a misnomer for shareware.
and Freeware was trademarked by Fluegelman and could not be used legally by others, and User-Supported Software was too cumbersome. So columnist Nelson Ford had a contest to come up with a better name. The most popular name submitted was Shareware, which was being used by Wallace. However, Wallace acknowledged that he got the
term from an InfoWorld magazine column by that name in the 1970s[failed verification][citation needed], and that he considered the name to be generic, [21] so its use became established over freeware and user-supported software. [22] By 1984 Knopf reported receiving about $1,000 a day for PC-File, [23] and by 1985 Fluegelman was receiving
"dozens of $35 checks" daily. He had two employees to fulfill orders and answer questions for PC-Talk.[19] He, Knopf, and Wallace clearly established shareware as a viable software distribution model by becoming wealthy.[24][25] Prior to the popularity of the World Wide Web and widespread Internet access, shareware was often the only
economical way for independent software authors to get their product onto users' desktops. Those with Internet or BBS access could download software and distribute it amongst their friends or user groups, who would then be encouraged to send the registration fee to the author, usually via postal mail. During the late 1980s and early 1990s
shareware software was widely distributed over online services, bulletin board systems and on diskettes. Contrary to commercial developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users to upload the software and shareware distributors such as Educorpose and shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions of dollars urging users "Don't Copy That Floppy", shareware developers who spent millions are users and the spent millions of dolla
and Public Domain Inc printed catalogs describing thousands of public domain and shareware programs that were available for a small charge on floppy disk. These companies later made their entire catalog available for a small charge on floppy disk. These companies later made their entire catalog available for a small charge on floppy disk. These companies later made their entire catalog available for a small charge on floppy disk. These companies later made their entire catalog available for a small charge on floppy disk.
no means of accepting credit card orders. Meanwhile major online service provider CompuServe enabled people to pay (register) for software using their CompuServe accounts. When AOL bought out CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using their CompuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe enabled people to pay (register) for software using the compuServe en
placed the service on to the internet and enabled over 3,000 independent software developers to use SWREG as a back office to accept various payment methods including credit, debit and charge cards, Paypal and other services in multiple currencies. This worked in realtime so that a client could pay for software and instantly download it which was
novel at the time. SWREG was eventually bought by Digital River, Inc. Also, services like Kagi started offering applications that authors could distribute along with their payment. Once telecommunications became more widespread, this service also
expanded online. Toward the beginning of the Internet era, books compiling reviews of available shareware were published, sometimes targeting specific niches such as small business. These books would typically come with one or more floppy disks or CD-ROMs containing software from the book. [26] As Internet use grew, users turned to
downloading shareware programs from FTP or web sites. This spelled the end of bulletin board systems and shareware disk distributors. At first, disk space on a server was hard to come by, so networks like Info-Mac were developed, consisting of non-profit mirror sites hosting large shareware libraries accessible via the web or ftp. With the advent of
the commercial web hosting industry, the authors of shareware programs started their own sites where the public could learn about their programs and download the latest versions, and even pay for the software online. This erased one of the chief distinctions of shareware, as it was now most often downloaded from a central "official" location
instead of being shared samizdat-style by its users. To ensure users would get the latest bug-fixes as well as an install untainted by viruses or other malware, some authors discouraged users from giving the software to their friends, encouraging them to send a link instead. Major download sites such as VersionTracker and CNet's Download.com
began to rank titles based on quality, feedback, and downloads. Popular software was sorted to the top of the list, along with products whose authors paid for preferred placement. If features are disabled in the freely accessible version, paying may provide the user with a license key or code they can enter into the software to disable the notices and
enable full functionality. Some pirate web sites publish license codes for popular shareware, leading to a kind of arms race between the developer and the pirates where the developer disables pirated codes and the pirates attempt to find or generate new ones. Some software publishers have started accepting known pirated codes, using the
opportunity to educate users on the economics of the shareware model. [27] Some shareware relies entirely on the user's honesty and required to disable the registration notices. [28] Main article: Game demo This article needs additional citations for
verification. Please help improve this article by adding citations to reliable sources. "Shareware" - news · newspapers · books · scholar · JSTOR (December 2016) (Learn how and when to remove this message) In the early 1990s, shareware distribution was a popular method of
publishing games for smaller developers, including then-fledgling companies Apogee Software (also known as 3D Realms), Epic MegaGames (now Epic Games), Ambrosia Software and id Software and 
retail space. With the Kroz series, Apogee introduced the "episodic" shareware model that became the most popular incentive for buying a game. [30] While the shareware and could only be legally obtained by paying for the shareware
episode. In some cases these episodes were neatly integrated and would feel like a longer version of the game, and in other cases the later episodes would be stand-alone games. Sometimes the additional content was completely integrated with the unregistered game, such as in Ambrosia's Escape Velocity series, in which a character representing the
developer's pet parrot, equipped with an undefeatable ship, would periodically harass and destroy the player after they reached a certain level representing the end of the trial period. Racks of games on single 5 1/4-inch and later 3.5-inch floppy disks were common in retail stores. However, computer shows[citation needed] and bulletin board systems
(BBS) such as Software Creations BBS were the primary distributors of low-cost software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivating force for consumers to purchase a computer equipped with a modem, so as to acquire software from a BBS was the motivation of the force for consumers and the force force for consumers and the force for consumers and the force force for consumers and the force for consumers and the force force for consumers and the force force force for consumers and the force force force force for consumers and the force force
on the BBS community's willingness to redistribute them from one BBS to another across North America. The reasons for redistribution included allowing modem users who could not afford long-distance calls the opportunity to view the games.[31] The important distinguishing feature between a shareware game and a game demo is that the
shareware game is (at least in theory) a complete working software program albeit with reduced content such as the first of
three episodes, while some even offered the entire product as shareware while unlocking additional content for registered users. By contrast a game demo may offer as little as one single-player level or consist solely of a multiplayer map, this makes them easier to prepare than a shareware game. There are several widely accepted standards and
technologies that are used in the development and promotion of shareware. FILE ID.DIZ is a description (PAD) is used to standardize shareware application descriptions. PAD file is an XML document that describes a shareware or freeware
product according to the PAD specification [32] Dynamic PAD extends the Portable Application Description (PAD) standard by allowing shareware vendors to provide customized PAD XML files to each download site or any other PAD-enabled resource. Dynamic PAD is a set of server-side PHP scripts distributed under a GPL license and a freeware
DynamicPAD builder for 32-bit Windows. The primary way to consume or submit a DynamicPAD is available at the DynamicPAD web site. Code signing is a technology that is used by developers to digitally sign their products. Versions of Microsof
Windows since Windows XP Service Pack 2 show a warning when the user installs unsigned software from potentially infecting the machine with malware. However, critics see this technology as part of a tactic to delegitimize independent software development by requiring
hefty upfront fees and a review process before software Profitable and Popular". The Kingston Whig-Standard (Kingston, Ontario, Canada). p. 17. ^ Gnoffo Jr., Anthony (July 4, 1993). "The Shareware Computer Industry, A
Growing World Of Innovation, Trust". Night-Ridder Newspapers. Rutland Daily Herald (Rutland, Vermont). p. 8D. Alvarez, Julian; Michaud, Laurent (July 2008). Serious Games: Advergaming, edugaming, training and more (PDF). IDATE. p. 45. ISBN 978-2-84822-169-4. Retrieved June 4, 2022. Flynn, Laurie (November 14, 1993). "Cheap, Easy
Shareware Big Business". Knight-Ridder Newspapers. Sun Herald (Biloxi, Mississippi). p. C7. ^ Jepson, Anna; Lundin, Elin (April 3, 2009). Freemium for large enterprises (Thesis). KTH Royal Institute of Technology. p. 14. urn:nbn:se:kth:diva-99781. ^ Wang, Wallace (2006). "Adware and Spyware". Steal This Computer Book 4.0: What They Won't Tell You About the Internet. No Starch Press. p. 285. ISBN 1-59327-105-0. Retrieved June 4, 2022. ^ Sipior, Janice C.; Ward, Burke T.; Roselli, Georgina R. (Spring 2005). "The Ethical and Legal Concerns of Spyware". Information Systems Management. 22 (2): 43. doi:10.1201/1078/45099.22.2.20050301/87276.5. S2CID 26291227. ^ Franceschetti, Donald
R. (2016). Principles of Computer Science. Salem Press. pp. 112-114. ISBN 978-1-68217-139-4. Milian, Mark (June 13, 2011). "Reading apps sell subscriptions to fuzzy feelings". CNN. Archived from the original on May 22, 2014. Parberry, Ian (June 1995). "The Internet and the Aspiring Games Programmer" (PDF).
Proceedings of DAGS 95, "Electronic Publishing and the Information Superhighway". Boston: Birkhauser. p. 2. Archived (PDF) from the original on March 4, 2016. ^ "Exifer for Windows". www.friedemann-schmidt.com. Archived
from the original on November 12, 2006. Retrieved January 18, 2016. ^ Torvalds, Linus (May 2001). Just for Fun. New York: HarperCollins Publishers. ISBN 0-06-662072-4. ^ Jump 'n Bump (Archived 2015-12-22 at the Wayback Machine). readme.txt: "JUMP 'N BUMP by Brainchild Design in 1998 Jump 'n Bump is e-mailware. That means you're
supposed to send us an e-mail. Write for example where you're from and what you thought about this game. If you do that, you will greatly encourage us to make more games for you!" ^ "Postcards". ^ Magid, Lawrence J. (August 1982). "PC-Talk". PC Magazine. p. 143. Archived from the original on May 26, 2021. Retrieved October 21, 2013. ^
Callahan, Michael E. "The History of Shareware". Paul's Picks. Archived from the original on February 2, 2008. Retrieved May 13, 2008. ^ Horizon: Psychedelic science by Bill Eagles, (about 41 mins into programme) ^ a b Erokan, Dennis (May 1985). "Andrew Fluegelman - PC-Talk and Beyond". MicroTimes. pp. 19-26. Retrieved March 12, 2025.
Pournelle, Jerry (July 1983). "Interstellar Drives, Osborne Accessories, DEDICATE/32, and Death Valley". BYTE. p. 323. Retrieved August 28, 2016. ^ Markoff, John (September 26, 2002). "Bob Wallace, 53, Software Pioneer, Dies". The New York Times. Archived from the original on June 25, 2016. Retrieved May 26, 2016. ^ "Association of Software Pioneer, Dies".
Professionals - A community of real people using real names running real software businesses". www.asp-shareware.org. Archived from the original on April 2, 2010. Retrieved April 28, 2018. ^ "Bob Wallace Timeline". Erowid. January 12,
2004. Archived from the original on March 2, 2013. Retrieved March 7, 2013. Archived from the original on August 17, 2021. Retrieved April 1, 2015. Archived from Dr. Dobb's Journal Archived from the original on August 17, 2021. Retrieved April 1, 2015. Archived from Dr. Dobb's Journal Archived from the original on August 17, 2021. Retrieved April 1, 2015. Archived from Dr. Dobb's Journal Archived from the original on August 17, 2021. Retrieved April 1, 2015. Archived from Dr. Dobb's Journal Archived from Dr. Dobb's Journal
Guiltyware". Archived from the original on May 24, 2014. ^ "FTP". Archived from the original on October 28, 2015. If you purchase a site license, contact me for information on how to make Anarchie automatically set the OI PaidÓ flag in the Preferences
dialog (for those who are interested, I leave the ÒI PaidÓ checkbox off on my machine to ensure that the About box is not too annoying and it doesnÕt trouble me, so live with it :-) ^ Hague, James (February 8, 1999). "Gimme Your Money: A Half-Baked History of Shareware". Loonygames. Archived from the original on February 23, 2020. Retrieved
February 23, 2020. ^ Driscoll 2022, pp. 117-120. ^ "PAD specification". Archived from the original on October 18, 2016. Retrieved April 28, 2018. Driscoll, Kevin
(2022). The Modem World: A Prehistory of Social Media. Yale University Press. ISBN 978-0-300-24814-2. Retrieved June 4, 2022. Look up shareware in Wiktionary, the free dictionary. Independent Software Developers Forum (ISDEF) Retrieved June 4, 2022. Look up shareware in Wiktionary, the free dictionary. Independent Software Developers Forum (ISDEF) Retrieved June 4, 2022. Look up shareware in Wiktionary.
Apogee Entertainment. 3D Realms Entertainment ApSFormerlyApogee Software ProductionsApogee Software, Ltd.Company typeSubsidiaryIndustryVideo gamesFounded1987; 38 years ago (1987) in Garland, Texas, USFounderScott MillerHeadquartersAalborg, DenmarkKey peopleFrederik Schreiber (CEO)ProductsList of 3D Realms
gamesParentSaber Interactive (2021-present)Website3drealms.com 3D Realms Entertainment ApS is a video game publisher based in Aalborg, Denmark. Scott Miller founded the company in his parents' home in Garland, Texas, in 1987 as Apogee Software Productions to release his game Kingdom of Kroz. In the late 1980s and early 1990s, the
company popularized a distribution model where each game consists of three episodes, with the first given away free as shareware and the other two available for purchase. Duke Nukem was a major franchise created by Apogee began using the
brand name 3D Realms for its 3D games in 1994, and in 1996 rebranded the company itself to 3D Realms to focus on two extensively delayed games: Prey
(2006), which was under development until being taken over by another studio in 2001, and Duke Nukem Forever (2011), which remained under development until 2009. The "Apogee Software" name, library, and logo were licensed to Terry Nagy in 2008, who established Apogee Software LLC to develop and publish ports and spinoffs of Apogee
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Section 1. Despite the section of th	
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