Exhibit 7

Google Chrome Memory Usage - Good and Bad

Friday, September 19, 2008

A lot of smart people are doing some serious tire kicking on Google Chrome. Now with several days of testing under their belts, we're seeing many observations about Google Chrome's memory usage. I've just posted a techie document about memory over on the developer website as an initial brain-dump of our current thinking about memory usage within Google Chrome. This article is a quick summary.

Measuring memory

If you're measuring memory in a multi-process application like Google Chrome, don't forget to take into account shared memory. If you add the size of each process via the Windows XP task manager, you'll be double counting the shared memory for each process. If there are a large number of processes, double-counting can account for 30-40% extra memory size.

To make it easy to summarize multi-process memory usage, Google Chrome provides the "about:memory" page which includes a detailed breakdown of Google Chrome's memory usage and also provides basic comparisons to other browsers that are running.

Multi-process Model Disadvantages

While the multi-process model provides clear robustness and performance benefits, it can also be a setback in terms of using the absolute smallest amount of memory. Since each tab is its own "sandboxed" process, tabs cannot share information easily. Any data structures needed for general rendering of web pages must be replicated to each tab. We've done our best to minimize this, but we have a lot more work to do.

Example: Try opening the browser with 10 different sites in 10 tabs. You will probably notice that Google Chrome uses significantly more memory than single-process browsers do for this case.

Keep in mind that we believe this is a good trade-off. For example; each tab has it's own JavaScript engine. An attack compromising one tab's Javascript engine is much less likely to be able to gain access to another tab (which may contain banking information) due to process separation. Operating systems vendors learned long ago that there are many benefits to not having all applications load into a single process space, despite the fact that multiple processes do incur overhead.

Multi-process advantages

Despite the setback, the multi-process model has advantages too. The primary advantage is the ability to partition memory for particular pages. So, when you close a page (tab), that partition of memory can be completely cleaned up. This is much more difficult to do in a single-process browser.

To demonstrate, lets expand on the example above. Now that you have 10 open tabs in a single process browser and Google Chrome, try closing 9 of them, and check the memory usage. Hopefully, this will demonstrate that Google Chrome is actually able to reclaim more memory than the single process browser generally can. We hope this is indicative of general user behavior, where many sites are visited on a daily basis; but when the user leaves a site, we want to cleanup everything.

You can find even more details in the design doc in our Chromium developer website.

Posted by Mike Belshe, Software Engineer

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The Chromium OS designs and code are preliminary. Expect them to evolve.

The Chromium projects include Chromium and Chromium OS, the open-source projects behind the Google Chrome browser and Google Chrome OS, respectively. This site houses the documentation and code related to the Chromium projects and is intended for developers interested in learning about and contributing to the open-source projects.

Chromium

Chromium is an open-source browser project that aims to build a safer, faster, and more stable way for all users to experience the web. This site contains design documents, architecture overviews, testing information, and more to help you learn to build and work with the Chromium source code.

Looking for Google Chrome?

Download Google Chrome

Chromium OS

Chromium OS is an open-source project that aims to provide a fast, simple, and more secure computing experience for people who spend most of their time on the web. Learn more about the project goals, obtain the latest build, and learn how you can get involved, submit code, and file bugs.

Want more information on the availability of devices running Google Chrome OS?

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High-Level Developer FAQ

If you don't find an answer to your question in this FAQ, check the discussion groups.

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What's the high-level difference between Google Chrome OS and Chromium OS?

Google Chrome OS is to Chromium OS what Google Chrome browser is to Chromium.

- **Chromium OS** is the open source project, used primarily by developers, with code that is available for anyone to checkout, modify, and build.
- **Google Chrome OS** is the Google product that OEMs will ship on Netbooks this year.

Some specific differences:

- The two projects fundamentally share the same code base, but Google Chrome OS has some additional firmware features, including verified boot and easy recovery, which require corresponding hardware changes and thus don't work in Chromium OS builds.
- Google Chrome OS runs on specially optimized hardware in order to get enhanced performance and security.
- Chromium OS does not auto-update (so that changes you make to the code are not blown away), whereas Google Chrome OS seamlessly auto-updates so that users have the latest and greatest features and fixes.
- Google Chrome OS is supported by Google and its partners; Chromium OS is supported by the open source community.

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Should I call my build Chromium OS or Google Chrome OS?

You should call it Chromium OS.

Will the autoupdate feature work on both Google Chrome OS and Chromium OS?

We don't plan to support autoupdate on Chromium OS, as we did not build the binaries, and we don't know what modifications you've made to the system, so we don't want to blow away any changes you may have made to the code. Therefore Google will not autoupdate Chromium OS systems, but you're welcome to set up your own autoupdate server.

Google Chrome OS will autoupdate to keep consumer machines running the latest and greatest at all times.

Will the verified boot feature work on both Google Chrome OS and Chromium OS?

The verified boot procedure relies on custom firmware and hardware modifications and hence will work only with Google Chrome OS netbooks.

Where can I download Google Chrome OS?

Google Chrome OS is not a conventional operating system that you can download or buy on a disc and install. As a consumer, the way you will get Google Chrome OS is by buying a netbook that has Google Chrome OS installed by the OEM. Google Chrome OS is being developed to run on new machines that are specially optimized for increased security and performance. We are working with manufacturers to develop reference hardware for Google Chrome OS. These netbooks will be available in the fourth quarter of 2010.

If you are the kind of developer who likes to build an open source operating system from scratch, you can check out Chromium OS, build it and experiment with it. A number of sites have also posted pre-built binaries of Chromium OS. However, these downloads are not verified by Google, therefore please ensure you trust the site you are downloading these from.

Keep in mind that Chrome OS is not yet ready for general consumer use.

What are the minimum hardware requirements?

The open-source nature of Chromium OS allows it to be ported to an expanding range of hardware; however, some base requirements are likely to remain fixed.

Hardware-accelerated OpenGL or OpenGL ES support is mandatory, and the Chromium browser's memory footprint is an obvious lower bound for RAM.

See the Developer Hardware list for examples of netbooks on which developers are successfully running Chromium OS.

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What about other hardware: Does Chromium OS support my wifi card?

In order to ensure the best user experience with Google Chrome OS, we're going through a careful hardware selection and testing process for hardware components.

For Chromium OS, the open source community and Google are working to add support for a very broad range of hardware. If the device you're interested in has an open source driver already in the upstream Linux kernel, please send a request to chromium-os-dev@googlegroups.com -- if you can include a proposed patch, even better.

Please see our supported developer hardware wiki for more details.

Is it true that you don't support hard disk drives (HDDs)?

Firstly, we should point out that the information in the open source release has been misinterpreted as saying that we don't support local storage. We do, but we are asking our hardware partners for Google Chrome OS to use solid state drives (SSDs) rather than hard disk drives (HDDs), for performance and reliability reasons.

Secondly, this restriction doesn't apply to Chromium OS: It will work with conventional HDDs, though the disk accesses are optimized for flash-based storage, like reduced read-ahead.

Chromiums OS issues

I can't log in

Login may fail under various circumstances. For example, if you do not have network connectivity and you have never logged in before, then you will not be able to log in.

The login screen should display a message beneath the username/password input field. For example, if you have network connectivity and provide the wrong credentials, you will be told that either your username or password is incorrect.

To troubleshoot networking at this point, you have to jump to a virtual terminal (only enabled on dev machines) by using Ctrl+Alt+F2 and entering the shared user password that you optionally set as part of the build process. If you did not set this field, you will not be able to debug networking and should plug into Ethernet at your earliest convenience.

If you are able to log in to the virtual terminal, reconfigure the networking service (sudo initctl restart flimflam). **Note:** If you are having trouble with wireless, just plug in an Ethernet cable. It is much easier to troubleshoot a networking issue once you have logged in.

For more information about login errors, look at the log files:

- /var/log/libcros_log - logging related to chromium's interaction with system services
- /home/chronos/chrome_log - login manager (which is, actually, chrome) logs

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I log in but the browser does not appear

If you do not have a black screen, try using the hotkey Ctrl+Alt+N to open a new window. If this doesn't work, check slim.log to verify whether it's an error in slim, or in something else. The logs you may be concerned about are:

- /var/log/messages
- /var/log/window_manager/chromoeos-wm.LATEST - for pre-login window manager logs
- /home/chronos/user/log/chromoeos-wm.LATEST - for post-login window manager logs

Wireless drops and does not reconnect

Drop into a terminal either through vt02 (Ctrl+Alt+F2) or Ctrl+Alt+T. Reconfiguring the connman service may fix the problem.

Miscellaneous

What are the shortcut keys?

To get a visual overlay, hit Ctrl-Alt-/ and then hold modifier keys like Ctrl, Alt, and Shift to see the associated hotkeys.

Most browser shortcuts also apply:
http://www.google.com/support/chrome/bin/answer.py?hl=en&answer=95743

Are native applications supported?

Google Chrome OS is a web-centric system, so all applications are web applications; this provides powerful and simple manageability and security. To write applications that will benefit from native code execution we recommend using NativeClient, an open source project that allows web apps to run native code securely within a browser. See http://code.google.com/p/nativeclient/ for more details.

Of course Chromium OS is open source, and it's Linux. This means that as a developer you can do pretty much anything you want, including installing any Linux application.

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The Chromium Projects

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Chromium OS FAQ

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Test Flights Into the Google Cloud

By BRAD STONE
Published: May 8, 2010

JORDON WING is a devoted user of Google products like Gmail, the Chrome browser and Google Docs, the Web-based word processing program.

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Steve Forrest for The New York Times

Liam McLoughlin, 17, has compiled Google's open-source code into a working version of its planned Chrome OS. His mother, Stefanie, brought him a snack.

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A few weeks ago, Mr. Wing, a high school student from Spokane, Wash., took another Google product out for a spin: the Chrome Operating System.

Google is not expected to unveil the highly anticipated Chrome OS until the end of the year, and the software is expected to run, at first, only on the class of low-cost PCs called netbooks. But Mr. Wing, along with a growing number of other Google fans, did not want to wait.

These people are downloading home-brewed versions of the operating system derived from the esoteric source code, which Google releases under the name Chromium. Google is developing the Chrome system as an open-source project and periodically releases the Chromium code online, to let other Web developers contribute to the project.

Several resourceful users have taken those undistilled vats of source code and done something Google says it never expected: they've compiled it into working versions of the operating system, tailoring it for use on dozens of computer brands and making it available to regular folks who want to preview one possible vision of their high-tech future.

"Maybe it's because I'm still kind of a kid, but all this new stuff is exciting," said Mr. Wing, who installed Chromium on his Dell Inspiron laptop and recently extolled its virtues. "The idea of an operating system that really only does one thing — gets you onto the Internet very quickly — is perfect for me."

When officially released, Chrome OS will represent a milestone for Google. It will not only be its entry into the market for operating systems, long dominated by its archrival Microsoft, but also a new computing paradigm.

The Chrome operating system is designed to allow computers to boot up to the Web within seconds, onto a home screen that looks like that of a Web browser. Users of devices running Chrome will have to perform all their computing online or "in the cloud," without downloading traditional software applications like iTunes and Microsoft Office, or storing files on hard drives. Devices running Chrome will receive continuous software updates,

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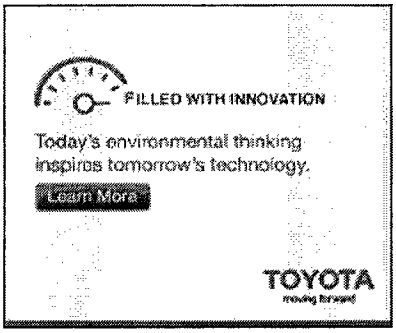

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providing added security, and most user data will reside on Google's servers.

Some analysts are skeptical that regular folks will flock to devices that place such severe limits on their computing activities. Chrome OS "is a bet on a future in which we move beyond rich applications and everything eventually gets delivered through a Web browser," said Michael Gartenberg, an analyst at the research firm Interpret. But that time is not here yet, he said: "Chrome this year and next year is mostly a science project."

But for legions of Google heads, the fact that it feels like a science project adds to the allure. Working versions of Chromium have appeared across the Web and have been downloaded more than a million times. By all accounts, the most popular and functional have been on the Web site of a 17-year-old in Manchester, England, who goes by the Internet handle "Hexxeh."

Liam McLoughlin, as Hexxeh is known to family and friends, is a college student and programmer who has taken Google's Chromium code and compiled it so the operating system can be downloaded to a separate USB memory stick, which can then be used to boot up a computer. He has spent countless evenings and weekends configuring Chromium to work on various kinds of computers, including the Macintosh, and added features that Google has not gotten to yet, like support for the Java programming language.

He explained that his work on Chromium began partly as a way to demonstrate his computing skills and possibly open doors in the technology industry. It also sprang from an interest and belief in Google's computing vision. "Many people don't care about how PCs work and all the security software that comes with today's computers. They just want to use the Internet," he said.

Since last fall, a small but vibrant community has formed around his work, encouraging him with ideas and supporting his efforts by providing money for servers and other programming tools.

Steve Pirk, a former systems engineer at the Walt Disney Company and now based in the Seattle area, helped to support a coding marathon this year by donating $50 via PayPal, which Mr. McLoughlin spent on a supply of highly caffeinated Jolt cola.

Mr. Pirk said he tested Hexxeh's resulting software, code-named Flow, on a half-dozen computers; all functioned properly running Chromium from a USB drive. He says he looks forward to the day when low-powered but fully functional computers running Chrome can help lead to a new wave of telecommuting. "The more work we do in the cloud, the less need there is for people to be in physically secure network environments," he said.

All of the activity around these prenatal incarnations of Chrome is something of a double-edged sword for Google. The company wants developers and other companies to work beside its engineers, developing their own versions of the operating system. But Google says it did not anticipate that regular people would start using Chromium — and evaluating it — before it was ready for prime time.

NEVERTHELESS, the Google executive in charge of Chrome OS took pains to express support for the Google fans trying Chromium — and for their presumptive band leader, Mr. McLoughlin.

Sundar Pichai, vice president of product management, said that "what people like Hexxeh are doing is amazing to see." Though he called the Chromium releases an "unintended consequence" of the process of developing open-source software, he said, "If you decide to do open-source projects, you have to be open all the way."

A version of this article appeared in print on May 9, 2010, on page BU3 of the New York edition.

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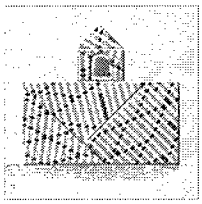

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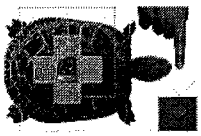

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