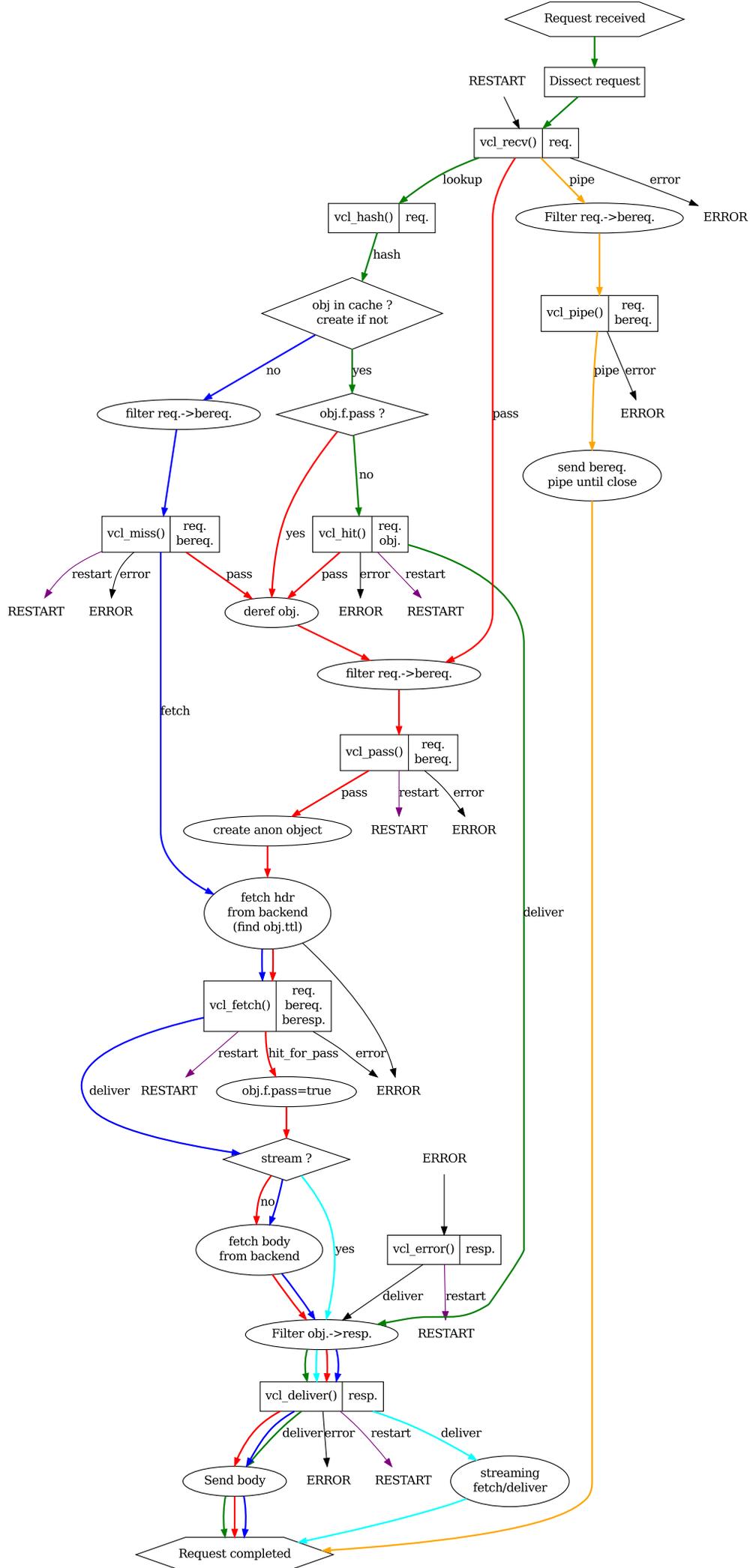




The Varnish Book



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Versions: Documentation version-4.7-58-g56edce8-dirty / Tested for Varnish 3.0.4

Date: 2013-07-08

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Web: <http://www.varnish-software.com/book/>

Source: <http://github.com/varnish/Varnish-Book/>

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1 Introduction

- About the course
- Goals and prerequisites
- Introduction to Varnish
- History
- Design Principles



1.1 About the course

The course is split in two:

1. Architecture, command line tools, installation, parameters, etc
2. The Varnish Configuration Language

The course has roughly 50% exercises and 50% instruction, and you will find all the information on the slides in the supplied training material.

The supplied training material also has additional information for most chapters.

The Varnish Book includes the material for both the *Varnish System Administration* course and the *Varnish for Web developers* course.

The agenda is adjusted based on the progress made. There is usually ample time to investigate specific aspects of Varnish that may be of special interest to some of the participants.

The exercises will occasionally offer multiple means to reach the same goals. Specially when you start working on VCL, you will notice that there are almost always more than one way to solve a specific problem, and it isn't necessarily given that the solution offered by the instructor or this course material is better than what you might come up with yourself.

Always feel free to interrupt the instructor if something is unclear.



1.2 Goals and Prerequisites

Prerequisites:

- Comfortable working in a shell on a Linux/UNIX machine, including editing text files and starting daemons.
- Basic understanding of HTTP and related internet protocols

Goals:

- Thorough understanding of Varnish
- Understanding of how VCL works and how to use it

The course is oriented around a GNU/Linux server-platform, but the majority of the tasks only require minimal knowledge of GNU/Linux.

The course starts out by installing Varnish and navigating some of the common configuration files, which is perhaps the most UNIX-centric part of the course. Do not hesitate to ask for help.

The goal of the course is to make you confident when using Varnish and let you adjust Varnish to your exact needs. If you have any specific area you are particularly interested in, the course is usually flexible enough to make room for it.



1.3 Introduction to Varnish

- What is Varnish?
- Open Source / Free Software
- History
- Varnish Governance Board (VGB)

Varnish is a reverse HTTP proxy, sometimes referred to as a HTTP accelerator or a web accelerator. It stores files or fragments of files in memory, allowing them to be served quickly. It is essentially a key/value store, that usually uses the URL as a key. It is designed for modern hardware, modern operating systems and modern work loads.

At the same time, Varnish is flexible. The Varnish Configuration Language is lightning fast and allows the administrator to express their wanted policy rather than being constrained by what the Varnish developers want to cater for or could think of. Varnish has shown itself to work well both on large (and expensive) servers and tiny appliances.

Varnish is also an open source project, and free software. The development process is public and everyone can submit patches, or just take a peek at the code if there is some uncertainty as to how Varnish works. There is a community of volunteers who help each other and newcomers. The BSD-like license used by Varnish does not place significant restriction on re-use of the code, which makes it possible to integrate Varnish in virtually any solution.

Varnish is developed and tested on GNU/Linux and FreeBSD. The code-base is kept as self-contained as possible to avoid introducing out-side bugs and unneeded complexity. As a consequence of this, Varnish uses very few external libraries.

Varnish development is governed by the Varnish Governance Board (VGB), which thus far has not needed to intervene. The VGB consists of an architect, a community representative and a representative from Varnish Software. As of March 2012, the positions are filled by Poul-Henning Kamp (Architect), Rogier Mulhuijzen (Community) and Kristian Lyngstøl (Varnish Software). On a day-to-day basis, there is little need to interfere with the general flow of development.

For those interested in development, the developers arrange weekly bug washes were recent tickets and development is discussed. This usually takes place on Mondays around 12:00 CET on the IRC channel *#varnish-hacking* on *irc.linpro.net*.



1.4 Design principles

- Solve real problems
- Optimize for modern hardware (64-bit, multi-core, etc)
- Work with the kernel, not against it
- Innovation, not regurgitation

The focus of Varnish has always been performance and flexibility. That has required some sacrifices.

Varnish is designed for hardware that you buy today, not the hardware you bought 15 years ago. Varnish is designed to run on 64-bit architectures and will scale almost proportional to the number of CPU cores you have available. Though CPU-power is rarely a problem.

If you choose to run Varnish on a 32-bit system, you are limited to 3GB of virtual memory address space, which puts a limit on the number of threads you can run and the size of your cache. This is a trade-off to gain a simpler design and reduce the amount of work Varnish needs to do. The 3GB limit depends on the operating system kernel. The theoretical maximum is 4GB, but your OS will reserve some of that for the kernel. This is called the user/kernel split.

Varnish does not keep track of whether your cache is on disk or in memory. Instead, Varnish will request a large chunk of memory and leave it to the operating system to figure out where that memory really is. The operating system can generally do a better job than a user-space program.

Accept filters, epoll and kqueue are advanced features of the operating system that are designed for high-performance services like Varnish. By using these, Varnish can move a lot of the complexity into the OS kernel which is also better positioned to know what threads are ready to execute when.

In addition, Varnish uses a configuration language that is translated to C-code, compiled with a normal C compiler and then dynamically linked directly into Varnish at run-time. This has several advantages. The most practical of which is the freedom you get as a system administrator. You can use VCL to decide how you want to interface with Varnish, instead of having a developer try to predict every possible scenario. The fact that it boils down to C and a C compiler also gives you very high performance, and if you really wanted to, you could by-pass the VCL to C translation and write raw C code (this is called in-line C in VCL). In short: Varnish provides the features, VCL allow you to specify exactly how you use and combine them.

With Varnish 3 you also have Varnish Modules or simply vmods. These modules let you extend the functionality of the VCL language by pulling in custom-written features. Some examples include non-standard header manipulation, access to memcached or complex normalization of headers.

The shared memory log allows Varnish to log large amounts of information at almost no cost by having other applications parse the data and extract the useful bits. This reduces the lock-contention in the heavily threaded environment of Varnish. Lock-contention is also one of the reasons why Varnish uses a workspace-oriented memory-model instead of allocating the exact amount of space it needs at run-time.

To summarize: Varnish is designed to run on modern hardware under real work-loads and to solve real problems. Varnish does not cater to the "I want to make Varnish run on my 486 just because"-crowd. If it does work on your 486, then that's fine, but that's not where you will see our focus. Nor will you see us sacrifice performance or simplicity for the sake of niche use-cases that can easily be solved by other means - like using a 64-bit OS.



1.5 How objects are stored

- Objects in Varnish are stored in a hash
- You can control the hashing
- Multiple objects can have the same hash key

Varnish has, as mentioned, a key/value store in its core. Objects are stored in memory and a reference to this object is kept in a hash tree.

A rather unique feature of Varnish is that you can actually control what goes into the hashing algorithm that Varnish uses to store data. Typically the key is made out of the HTTP Host header and the URL, but you're actually able to override this if you should choose to do so.

The HTTP protocol specifies that there can be multiple objects that can be served on the same URL, depending on the preferences of the client. For instance, serving gzip'ed content to a client that doesn't indicate gzip support doesn't make much sense and Varnish might look at the Various objects stored at that key to pick out the one that matches.



2 Getting started

In this chapter, we will:

- Install and test a backend
- Install Varnish
- Make Varnish and the backend-server work together
- Cover basic configuration

You want to use packages for your operating system whenever possible.

If the computer you will be using throughout this course has Varnish 3.0.0 or more recent available through the package system, you are encouraged to use that package if you do not feel you need the exercise in installing from source.

We will be using Apache as a web server.

This course is about Varnish, but we need an operating system to test. For the sake of keeping things simple, the course uses Debian as a platform. You will find several references to differences between Debian and Red Hat where they matter the most, but for the most part, this course is independent on the operating system in use.



2.1 Configuration

Varnish has two categories of configuration:

- Command line configuration and tunable parameters
- VCL

To re-load Varnish configuration, you have several commands:

Command	Result
<code>service varnish restart</code>	Completely restarts Varnish, using the operating system mechanisms. Your cache will be flushed.
<code>service varnish reload</code>	Only reloads VCL. Cache is not affected.
<code>varnishadm vcl.load ..</code> and <code>varnishadm vcl.use ..</code>	Can be used to manually reload VCL. The <code>service varnish reload</code> command does this for you automatically.
<code>varnishadm param.set ...</code>	Can be used to set parameters without restarting Varnish.

Using the `service` commands is recommended. It's safe and fast.

Tunable parameters and command line arguments are used to define how Varnish should work with operating system and hardware in addition to setting some default values, while VCL define how Varnish should interact with web servers and clients.

Almost every aspect of Varnish can be reconfigured without restarting Varnish. Notable exceptions are cache size and location, the username and group that Varnish runs as and hashing algorithm.

While you can change the values, some changes might require restarting the child to take effect (modifying the listening port, for instance) or might not be visible immediately. Changes to how long objects are cached, for instance, usually only take effect after the currently cached objects expire and are fetched again. Issuing `param.show <parameter>` will give you a description of the parameter, when and how it takes effect and the default and current value.



2.2 Command line configuration

<code>-a <[hostname]:port></code>	listen address
<code>-f <filename></code>	VCL
<code>-p <parameter=value></code>	set tunable parameters
<code>-S <secretfile></code>	authentication secret for management
<code>-T <hostname:port></code>	Management interface
<code>-s <storage type, options></code>	where and how to store objects

All the options that you can pass to the `varnishd` binary are documented in the `varnishd(1)` manual page (`man varnishd`). You may want to take a moment to skim over the options mentioned above.

The only option that is strictly needed to start Varnish is the `-f` to specify a VCL file.

Though they are not strictly required, you almost always want to specify a `-s` to select a storage backend, `-a` to make sure Varnish listens for clients on the port you expect and `-T` to enable a management interface, often referred to as a telnet interface.

Both for `-T` and `-a`, you do not need to specify an IP, but can use `:80` to tell Varnish to listen to port 80 on all IPs available. Make sure you don't forget the colon, as `-a 80` will tell Varnish to listen to the IP with the decimal-representation "80", which is almost certainly not what you want. This is a result of the underlying function that accept this kind of syntax.

You can specify `-p` for parameters multiple times. The workflow for tuning Varnish parameters usually means that you first try the parameter on a running Varnish through the management interface to find the value you want, then store it in a configuration file that will pass it to Varnish with `-p` next time you start it up. We will look at these files later on.

The `-S` option specifies a file which contains a secret to be used for authentication. This can be used to authenticate with `varnishadm -S` as long as `varnishadm` can read the same secret file - or rather the same content: The content of the file can be copied to another machine to allow `varnishadm` to access the management interface remotely.

Note

It is possible to start Varnish without a VCL file using the `-b` option instead of `-f`:

```
-b <hostname:port>                backend address
```

Since the `-b` option is mutually exclusive with the `-f` option, we will only use the `-f` option. You can use `-b` if you do not intend to specify any VCL and only have a single web server.



2.3 Configuration files

Most Varnish-installations use two configuration-files. One of them is used by the operating system to start Varnish, while the other contains your VCL.

File	Usage
<code>/etc/default/varnish</code>	Used for parameters and command line arguments. When you change this, you need to run <code>service varnish restart</code> for the changes to take effect. On RedHat-based OS's, this is kept in <code>/etc/sysconfig/varnish</code> instead.
<code>/etc/varnish/default.vcl</code>	The VCL file. You can change the file name by editing <code>/etc/default/varnish</code> if you want to, but it's normal to use the default name. This contains your VCL and backend-definitions. After changing this, you can run either <code>service varnish reload</code> , which will not restart Varnish, or you can run <code>service varnish restart</code> , which empties the cache.

There are other ways to reload VCL and make parameter-changes take effect, mostly using the `varnishadm` tool. However, using the `service varnish reload` and `service varnish restart` commands is a good habit.

Note

If you want to know how the `service varnish`-commands work, you can always look at the script that runs behind the scenes. If you are used to UNIX-like systems, it will come as no surprise that the script can be found in `/etc/init.d/varnish`.

Warning

The script-configuration (located in `/etc/sysconfig` or `/etc/default`) is directly sourced as a shell script. Pay close attention to any backslashes (`\`) and quotation marks that might move around as you edit the `DAEMON_OPTS` environmental variable.



2.4 Defining a backend in VCL

/etc/varnish/default.vcl

```
backend default {  
    .host = "localhost";  
    .port = "8080";  
}
```

In Varnish terminology, a backend-server is whatever server Varnish talks to to fetch content. This can be any sort of service as long as it understands HTTP. Most of the time, Varnish talks to a web server or an application frontend server.

You almost always want to use VCL so we might as well get started.

The above example defines a backend named `default`. The name *default* is not special, and the real default backend that Varnish will use is the first backend you specify.

You can specify many backends at the same time, but for now, we will only specify one to get started.



2.5 Exercise: Installation

You can install packages on Debian with `apt-get install <package>`. E.g: `apt-get install apache2`. For Red Hat, the tool would be `yum install <package>`.

1. Install `apache2` and verify it works by browsing to `http://localhost/`. You probably want to change `localhost` with whatever the hostname of the machine you're working is.
2. Change Apache's ports from 80 to 8080, in `/etc/apache2/ports.conf` and `/etc/apache2/sites-enabled/000-default`.
3. Install Varnish
4. Modify the Varnish configuration file so Varnish listens on port 80, has a management interface on port 1234 and uses `127.0.0.1:8080` as the backend.
5. Start Varnish using `service varnish start`.

The end result should be:

Service	Result	Related config-files
Apache	Answers on port <i>8080</i>	<code>/etc/apache2/ports.conf</code> and <code>/etc/apache2/sites-enabled/000-default</code>
Varnish	Answers on port <i>80</i>	<code>/etc/default/varnish</code>
Varnish	Talks to apache on <i>localhost:8080</i>	<code>/etc/varnish/default.vcl</code>

Varnish Software and the Varnish community maintains a package repository for several common GNU/Linux distributions. If your system does not have sufficiently up-to-date packages, visit <https://www.varnish-cache.org/releases> and find a package for your distribution.

Once you have modified the `/etc/default/varnish-file`, it should look something like this (comments removed):

```
NFILES=131072
MEMLOCK=82000
INSTANCE=$(uname -n)
DAEMON_OPTS="-a :80 \
             -T localhost:1234 \
             -f /etc/varnish/default.vcl \
             -s malloc,256m"
```

Tip

You can get an overview over services listening on TCP ports by issuing the command `netstat -nlpt`.



2.6 Exercise: Fetch data through Varnish

1. Install `libwww-perl`
2. Execute `GET -Used http://localhost:80/` (on the command line)
3. Compare the results from multiple executions.

GET and HEAD is actually the same tool; `lwp-request`. A HTTP HEAD request tells the web server - or Varnish in this case - to only reply with the HTTP headers, while GET returns everything.

`GET -Used` tells `lwp-request` to do a GET-request, print the request headers (U), print the response status code (s), which is typically "200 OK" or "404 File not found", print the response headers "-e" and finally to not display the content of the response. Feel free to try removing some of the options observe the effect.

GET is also useful to generate requests with custom headers, as you can supply extra headers with `-H "Header: value"`, which can be used multiple times.

You may also be familiar with `firebug`, an add-on for Firefox used for web development and related affairs. This too can show you the response headers.

Web browsers have their own cache which you may not immediately be able to tell if you're using or not. It's often helpful to double-check with GET or HEAD if you are in doubt if what you're seeing is coming from Varnish or is part of your browser cache.



2.7 Log data

Varnish provides a great deal of log data in real-time. The two most important tools to process that log data is:

- Varnishlog, used to access request-specific data (An extended access log, provides information about specific clients and requests.).
- varnishstat, used to access global counters (Provides overall statistics, e.g the number of total requests, number of objects and more.).
- If you have multiple Varnish instances on the same machine, you need to specify `-n <name>` both when starting Varnish and when starting the corresponding tools.

In addition the `varnishncsa-tool` is often used to write apache-like log files.

If you look for logging data for Varnish you may discover that `/var/log/varnish/` is either non-existent or empty. There's a reason for that.

Varnish logs all its information to a shared memory log which is overwritten repeatedly every time it's filled up. To use the log data, you need to use specific tools to parse the content.

The downside is that you don't have historic data unless you set it up yourself, which is not covered in this chapter, but the upside is that you get an abundance of information when you need it.

Through the course you will become familiar with `varnishlog` and `varnishstat`, which are the two most important tools you have at your disposal.

Note

If you want to log to disk you should take a look at `/etc/default/varnishlog` or `/etc/default/varnishncsa` (or the `syconfig` equivalents). This will allow you to run `varnishncsa` or `varnishlog` as a service in the background that writes to disk.

Keep in mind that `varnishlog` generates large amounts of data, though. You may not want to log all of it to disk.

Note

All log tools (and `varnishadm`) takes an `-n` option. Varnish itself also takes a `-n` option. This is used to specify a name for `varnishd`, or the location of the shared memory log. On most installations `-n` is not used, but if you run multiple Varnish instances on a single machine you need to use `-n` to distinguish one varnish-instance from another.



2.8 varnishlog

```

97 ReqStart      c 10.1.0.10 50866 117511506
97 RxRequest     c GET
97 RxURL         c /style.css
97 RxProtocol    c HTTP/1.1
97 RxHeader      c Host: www.example.com
97 VCL_call      c recv lookup
97 VCL_call      c hash hash
97 Hit           c 117505004
97 VCL_call      c hit deliver
97 Length        c 3218
97 VCL_call      c deliver deliver
97 TxProtocol    c HTTP/1.1
97 TxStatus      c 200
97 TxResponse    c OK
97 TxHeader      c Content-Length: 3218
97 TxHeader      c Date: Sat, 22 Aug 2008 01:10:10 GMT
97 TxHeader      c X-Varnish: 117511501 117505004
97 TxHeader      c Age: 2
97 TxHeader      c Via: 1.1 varnish
97 ReqEnd        c 117511501 1227316210.534358978 \
    1227316210.535176039 0.035283089 0.000793934 0.000023127

```

The above output is a single cache hit, as processed by Varnish. When you are dealing with several thousand requests per second you need filtering.

The displayed data is categorized as follows:

1. The number on the left is a semi-unique identifier of the request. It is used to distinguish different requests.
2. Each piece of log information belongs to a tag, as seen on the second left-most column. TxHeader, RxHeader, VCL_call etc. You can use those tags for intelligent filtering.
3. Varnishlog will try to decipher if a request is related to a client (c), backend (b) or "misc" (-). This can be used to filter the log. The misc-category will contain data related to thread-collection, object expiry and similar internal data.
4. The tag-specific content. E.g: the actual URL, the name and content of a HTTP header and so on.

Since varnishlog displays all data in the log unless you filter it, there is a lot of data that you can safely ignore, and some data you should focus on. The following table demonstrates some tags and values that are useful. Since the tags themselves are somewhat generic, you do not have a "Response header sent to a client"-header, but a "Sent Header" (*TxHeader*) tag, and it's up to you to interpret if that means it was sent to a client or a web server.



2.9 Varnishlog tag examples

Tag	Example value	Description
RxURL	/index.html	Varnish received a URL, the only scenario where Varnish receives a URL is from a client, thus: a client sent us this URL.
TxURL	/index.html	Varnish sent a URL, the only scenario where Varnish sends a URL is to a backend, thus: this is part of a backend request.
RxHeader	Host: www.example.com	A received header. Either a request header or a response header backend. Since we know the <i>Host</i> -header is a request header, we can assume it's from a client.
TxHeader	Host: example.com	A header Varnish sent. Either a request header or a response header. Since we know the <i>Host</i> -header is a request header we can assume it is a header Varnish sent to a backend.
RxRequest	GET	Received request method. Varnish only receives requests from clients.
TxStatus	200	Status code Varnish sent. Only sent to clients.
RxStatus	500	Status code Varnish received from a backend.
ReqEnd	1048725851 1352290440.688310385 1352290440.688468695 0.000107288 0.000083208 0.000075102	The "End of request" entry has various timing details for debugging. The first number is the <i>XID</i> , the second is the time the request started and the second is when it finished. The fourth number is time from accepting the connection to processing of the request started. The fifth number is time from request processing started to delivery (e.g: VCL execution and backend fetching). The sixth and last number is how long the delivery itself took.



2.10 varnishlog options

-b	Only show traffic to backend.
-c	Only show traffic to client.
-O	Do not group by request.
-m <tag:filter>	Show <i>requests</i> where the <tag> matches <filter>. Example: <code>varnishlog -m TxStatus:500</code> to show requests returned to a client with status code 500.
-n <name>	The name of the Varnish instance, or path to the shmlog. Useful for running multiple instances of Varnish.
-i <tag[,tag][...]>	Only show the specified tags.
-I <regex>	Filter the tag provided by -i, using the regular expression for -I.

Some examples of useful command-combinations:

Command	Description
<code>varnishlog -c -m RxURL:/specific/url/</code>	Only show client-requests for the url <i>/specific/url..</i>
<code>varnishlog -O -i ReqEnd</code>	Only show the ReqEnd tag. Useful to spot sporadic slowdown. Watch the last three values of it.
<code>varnishlog -O -i TxURL</code>	Only show the URLs sent to backend servers. E.g: Cache misses and content not cached.
<code>varnishlog -O -i RxHeader -I Accept-Encoding</code>	Show the Accept-Encoding request header.
<code>varnishlog -b -m TxRequest:POST</code>	Show backend requests using the POST method.
<code>varnishlog -O -i TxURL,TxHeader</code>	Only shows the URL sent to a backend server and all headers sent, either to a client or backend.

Warning

`varnishlog` sometimes accept arguments that are technically incorrect, which can have surprising results on filtering. Make sure you double-check the filter logic. You most likely want to specify `-b` or `-c` too.



2.11 varnishstat

```

0+00:44:50                                     foobar
Hitrate ratio:          10          100          175
Hitrate avg:           0.9507      0.9530      0.9532

    574660          241.00          213.63 Client connections accepted
    2525317         937.00          938.78 Client requests received
    2478794         931.00          921.48 Cache hits
      7723           3.00            2.87 Cache hits for pass
    140055          36.00           52.07 Cache misses
     47974          12.00           17.83 Backend conn. success
    109526          31.00           40.72 Backend conn. reuses
     46676           5.00           17.35 Backend conn. was closed
    156211          41.00           58.07 Backend conn. recycles
    110500          34.00           41.08 Fetch with Length
     46519           6.00           17.29 Fetch chunked
      456            0.00            0.17 Fetch wanted close
     5091            .              .      N struct sess_mem
     3473            .              .      N struct sess
    53570            .              .      N struct object
    50070            .              .      N struct objecthead
      20             .              .      N struct vbe_conn

```

varnishstat gives a good representation of the general health of Varnish, including cache hit rate, uptime, number of failed backend connections and many other statistics.

There are over a hundred different counters available. To increase the usefulness of varnishstat, only counters with a value different from 0 is shown by default.

varnishstat can be executed either as a one-shot tool which simply prints the current values of all the counters, using the `-l` option, or interactively. Both methods allow you to specify specific counters using `-f field1,field2,...` to limit the list.

In interactive mode, varnishstat starts out by printing the uptime(45 minutes, in the example above) and hostname(foobar).

The *Hitrate ratio* and *Hitrate avg* are related. The Hitrate average measures the cache hit rate for a period of time stated by *hitrate ratio*. In the example above, the hitrate average for the last 10 seconds is 0.9507 (or 95.07%), 0.9530 for the last 100 seconds and 0.9532 for the last 175 seconds. When you start varnishstat, all of these will start at 1 second, then grow to 10, 100 and 1000. This is because varnishstat has to compute the average while it is running; there is no historic data of counters available.

The bulk of varnishstat is the counters. The left column is the raw value, the second column is change per second in real time and the third column is change per second on average since Varnish started. In the above example Varnish has served 574660 requests and is currently serving roughly 241 requests per second.

Some counters do not have 'per second' data. These are counters which both increase and decrease.



There are far too many counters to keep track of for non-developers, and many of the counters are only there for debugging purposes. This allows you to provide the developers of Varnish with real and detailed data whenever you run into a performance issue or bug. It allows the developers to test ideas and get feedback on how it works in production environments without creating special test versions of Varnish. In short: It allows Varnish to be developed according to how it is used.

In addition to some obviously interesting counters, like *cache_hit* and *client_conn*, some counters of note are:

Counter	Description
<i>client_drop</i>	This counts clients Varnish had to drop due to resource shortage. It should be 0.
<i>cache_hitpass</i>	Hitpass is a special type of cache miss. It will be covered in the VCL chapters, but it can often be used to indicate if something the backend sent has triggered cache misses.
<i>backend_fail</i>	Counts the number of requests to backends that fail. Should have a low number, ideally 0, but it's not unnatural to have backend failures once in a while. Just make sure it doesn't become the normal state of operation.
<i>n_object</i>	Counts the number of objects in cache. You can have multiple variants of the same object depending on your setup.
<i>n_wrk</i> , <i>n_wrk_queued</i> , <i>n_wrk_drop</i>	Thread counters. During normal operation, the <i>n_wrk_queued</i> counter should not grow. Once Varnish is out of threads, it will queue up requests and <i>n_wrk_queued</i> counts how many times this has happened. Once the queue is full, Varnish starts dropping requests without answering. <i>n_wrk_drop</i> counts how many times a request has been dropped. It should be 0.
<i>n_lru_nuked</i>	Counts the number of objects Varnish has had to evict from cache before they expired to make room for other content. If it is always 0, there is no point increasing the size of the cache since the cache isn't full. If it's climbing steadily a bigger cache could improve cache efficiency.
<i>esi_errors</i> , <i>esi_warnings</i>	If you use Edge Side Includes (ESI), these somewhat hidden counters can be helpful to determine if the ESI syntax the web server is sending is valid.
<i>uptime</i>	Varnish' uptime. Useful to spot if Varnish has been restarted, either manually or by bugs. Particularly useful if a monitor tool uses it.



2.12 The management interface

Varnish offers a management interface (Historically called the Telnet interface.), assuming it was started with a `-T` option. You can use the management interface to:

- Change parameters without restarting varnish
- Reload VCL
- View the most up-to-date documentation for parameters

There are a few other uses too which you can read about using the `help`-command after you connect to the management interface with `varnishadm`.

The `service varnish reload` command uses the management interface to reload VCL without restarting Varnish.

Keep the following in mind when using the management interface:

1. Any changes you make are done immediately on the running Varnish instance.
2. Changes are not persistent across restarts of Varnish. If you change a parameter and you want the change to apply if you restart Varnish, you need to also store it in the regular configuration for the boot script.

Because the management interface is not encrypted, only has limited authentication and still allows almost total control over Varnish, it is important to protect it. Using the `-s` option offers reasonably good access control, but does not protect against more elaborate attacks, like man in the middle attacks -- the interface is not encrypted.

The simplest way to protect the management interface is to only have it listen on localhost (127.0.0.1). Combined with the secret file, you can now offer access to the interface on a user-by-user basis by adjusting the read permission on the secret file. The secret file usually lives in `/etc/varnish/secret`. The content is not a password, but a shared secret (it is never transmitted over the interface).

Note

Newer Varnish-versions will automatically detect the correct arguments for `varnishadm` using the shared memory log. For older versions, you always had to specify at least the `-T`-option when using `varnishadm`.

This automatic detection relies on the `-n` option since `varnishadm` needs to find the shared memory log.

For remote access you will always specify `-T` and `-S` since a remote `varnishadm` can't read the shared memory log.



2.13 Exercise: Try out the tools

1. Run `varnishstat` and `varnishlog` while performing a few requests.
2. Make `varnishlog` only print client-requests where the `RxURL`-tag contains `/favicon.ico`.
3. Use `varnishadm` to determine the default value for the `default_ttl`-parameter, and what it does.

As you are finishing up this exercise, you hopefully begin to see the usefulness of the various Varnish tools. `varnishstat` and `varnishlog` are the two most used tools, and are usually what you need for sites that are not in production yet.

The various arguments for `varnishlog` are mostly designed to help you find exactly what you want, and filter out the noise. On production traffic, the amount of log data that Varnish produces is staggering, and filtering is a requirement for using `varnishlog` effectively.



3 Tuning

This chapter is for the system administration course only

This chapter will cover:

- Architecture
- Best practices
- Parameters

Tuning Varnish is two-fold. Perhaps the most important aspect of it is getting your VCL straight. For now, though, we will focus on tuning Varnish for your hardware, operating system and network.

To be able to do that, knowledge of the process- and thread-architecture is helpful.

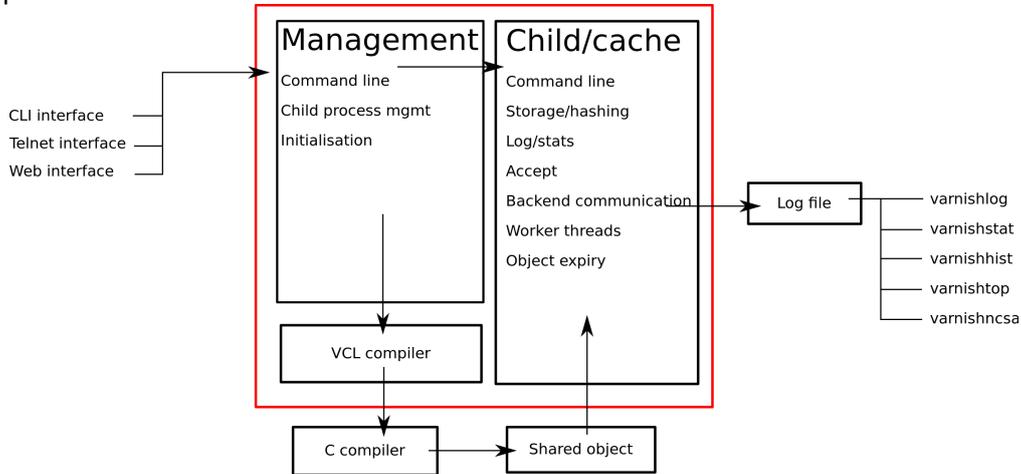
The internal architecture of Varnish is of some interest, both because it is chiefly responsible for the performance you will be able to achieve with Varnish, and because it affects how you integrate Varnish in your own architecture.

There are several aspects of the design that was unique to Varnish when it was originally implemented. Truly good solutions is the aim of Varnish, regardless of whether that means reusing ancient ideas or coming up with something radically different.



3.1 Process Architecture

The multi-process architecture:



3.1.1 The management process

Varnish has two main processes: the management process and the child process. The management process apply configuration changes (VCL and parameters), compile VCL, monitor Varnish, initialize Varnish and provides a command line interface, accessible either directly on the terminal or through a management interface.

The management process polls the child process every few seconds to see if it's still there. If it doesn't get a reply within a reasonable time, the management process will kill the child and start it back up again. The same happens if the child unexpectedly exits, for example from a segmentation fault or assert error.

This ensures that even if Varnish does contain a critical bug, it will start back up again fast. Usually within a few seconds, depending on the conditions.

All of this is logged to syslog. This makes it crucially important to monitor the syslog, otherwise you may never even know unless you look for them, because the perceived downtime is so short.

Note

Varnish Software and the Varnish community at large occasionally get requests for assistance in performance tuning Varnish that turn out to be crash-issues. Because the Varnish management thread starts the child up so fast, the users don't even notice the down time, only the extra loading time as Varnish is constantly emptying its cache.

This is easily avoidable by paying attention to syslog and the *uptime* counter in `varnishstat`.



3.1.2 The child process

The child process consist of several different types of threads, including, but not limited to:

- Acceptor thread to accept new connections and delegate them.
- Worker threads - one per session. It's common to use hundreds of worker threads.
- Expiry thread, to evict old content from the cache.

Varnish uses workspaces to reduce the contention between each thread when they need to acquire or modify memory. There are multiple workspaces, but the most important one is the session workspace, which is used to manipulate session data. An example is changing *www.example.com* to *example.com* before it is entered into the cache, to reduce the number of duplicates.

It is important to remember that even if you have 5MB of session workspace and are using 1000 threads, the actual memory usage is not 5GB. The virtual memory usage will indeed be 5GB, but unless you actually use the memory, this is not a problem. Your memory controller and operating system will keep track of what you actually use.

To communicate with the rest of the system, the child process uses a shared memory log accessible from the file system. This means that if a thread needs to log something, all it has to do is grab a lock, write to a memory area and then free the lock. In addition to that, each worker thread has a cache for log data to reduce lock contention.

The log file is usually about 80MB, and split in two. The first part is counters, the second part is request data. To view the actual data, a number of tools exist that parses the shared memory log. Because the log-data is not meant to be written to disk in its raw form, Varnish can afford to be very verbose. You then use one of the log-parsing tools to extract the piece of information you want - either to store it permanently or to monitor Varnish in real-time.

3.1.3 VCL compilation

Configuring the caching policies of Varnish is done in the Varnish Configuration Language (VCL). Your VCL is then interpreted by the management process into to C and then compiled by a normal C compiler - typically gcc. Lastly, it is linked into the running Varnish instance.

As a result of this, changing configuration while Varnish is running is very cheap. Varnish may want to keep the old configuration around for a bit in case it still has references to it, but the policies of the new VCL takes effect immediately.

Because the compilation is done outside of the child process, there is no risk of affecting the running Varnish by accidentally loading an ill-formated VCL.

A compiled VCL file is kept around until you restart Varnish completely, or until you issue `vcl.discard` from the management interface. You can only discard compiled VCL files after all references to them are gone, and the amount of references left is part of the output of `vcl.list`.



3.2 Storage backends

Varnish supports different methods of allocating space for the cache, and you choose which one you want with the `-s` argument.

- file
- malloc
- persistent (experimental)

Note

As a Rule of thumb use: malloc if it fits in memory, file if it doesn't. Expect around 1kB of overhead per object cached.

They approach the same basic problem from two different angles. With the *malloc*-method, Varnish will request the entire size of the cache with a `malloc()` (memory allocation) library call. The operating system divides the cache between memory and disk by swapping out what it can't fit in memory.

The alternative is to use the *file* storage backend, which instead creates a file on a filesystem to contain the entire cache, then tell the operating system through the `mmap()` (memory map) system call to map the entire file into memory if possible.

The *file* storage method does not retain data when you stop or restart Varnish! This is what persistent storage is for. When `-s file` is used, Varnish does not keep track of what is written to disk and what is not. As a result, it's impossible to know whether the cache on disk can be used or not — it's just random data. Varnish will not (and can not) re-use old cache if you use `-s file`.

While *malloc* will use swap to store data to disk, *file* will use memory to cache the data instead. Varnish allow you to choose between the two because the performance of the two approaches have varied historically.

The persistent storage backend is similar to file, but experimental. It does not yet gracefully handle situations where you run out of space. We only recommend using persistent if you have a large amount of data that you must cache and are prepared to work with us to track down bugs.

When choosing storage backend, the rule of thumb is to use malloc if your cache will be contained entirely or mostly in memory, while the file storage backend performs far better when you need a large cache that exceeds the physical memory available. This might vary based on the kernel you use, but seems to be the case for 2.6.18 and later Linux kernel, in addition to FreeBSD.

It is important to keep in mind that the size you specify with the `-s` argument is the size for the actual cache. Varnish has an overhead on top of this for keeping track of the cache, so the actual memory footprint of Varnish will exceed what the '-s' argument specifies if the cache is full. The current estimate (subject to change on individual Varnish-versions) is that about 1kB of overhead needed for each object. For 1 million objects, that means 1GB extra memory usage.

In addition to the per-object overhead, there is also a fairly static overhead which you can calculate by starting Varnish without any objects. Typically around 100MB.



3.3 The shared memory log

Varnish' shared memory log is used to log most data. It's sometimes called a shm-log, and operates on a round-robin capacity.

There's not much you have to do with the shared memory log, except ensure that it does not cause I/O. This is easily accomplished by putting it on a tmpfs.

This is typically done in `/etc/fstab`, and the shmlog is normally kept in `/var/lib/varnish` or equivalent locations. All the content in that directory is safe to delete.

The shared memory log is not persistent, so do not expect it to contain any real history.

The typical size of the shared memory log is 80MB. If you want to see old log entries, not just real-time, you can use the `-d` argument for *varnishlog*: `varnishlog -d`.

Warning

Some packages will use `-s file` by default with a path that puts the storage file in the same directory as the shmlog. You want to avoid this.



3.4 Tunable parameters

- In the CLI:

```
param.show -l
```

- Don't fall for the copy/paste tips
- Test the parameters in CLI, then store them in the configuration file

Varnish has many different parameters which can be adjusted to make Varnish act better under specific workloads or with specific software and hardware setups. They can all be viewed with `param.show` in the management interface and set with the `-p` option passed to Varnish - or directly in the management interface.

Remember that changes made in the management interface are not stored anywhere, so unless you store your changes in a startup script, they will be lost when Varnish restarts.

The general advice with regards to parameters is to keep it simple. Most of the defaults are very good, and even though they might give a small boost to performance, it's generally better to use safe defaults if you don't have a very specific need.

A few hidden commands exist in the CLI, which can be revealed with `help -d`. These are meant exclusively for development or testing, and many of them are downright dangerous. They are hidden for a reason, and the only exception is perhaps `debug.health`, which is somewhat common to use.



3.5 Threading model

- The child process runs multiple threads
- Worker threads are the bread and butter of the Varnish architecture
- Utility-threads
- Balance

The child process of Varnish is where the magic takes place. It consists of several distinct threads performing different tasks. The following table lists some interesting threads, to give you an idea of what goes on. The table is not complete.

Thread-name	Amount of threads	Task
cache-worker	One per active connection	Handle requests
cache-main	One	Startup
ban lurker	One	Clean bans
acceptor	One	Accept new connections
epoll/kqueue	Configurable, default: 2	Manage thread pools
expire	One	Remove old content
backend poll	One per backend poll	Health checks

Most of the time, we only deal with the cache-worker threads when configuring Varnish. With the exception of the amount of thread pools, all the other threads are not configurable.

For tuning Varnish, you need to think about your expected traffic. The thread model allows you to use multiple thread pools, but time and experience has shown that as long as you have 2 thread pools, adding more will not increase performance.

The most important thread setting is the number of worker threads.

Note

If you run across tuning advice that suggests running one thread pool for each CPU core, rest assured that this is old advice. Experiments and data from production environments have revealed that as long as you have two thread pools (which is the default), there is nothing to gain by increasing the number of thread pools.



3.6 Threading parameters

- Thread pools can safely be ignored
- Maximum: Roughly 5000 (total)
- Start them sooner rather than later
- Maximum and minimum values are per thread pool

3.6.1 Details of threading parameters

While most parameters can be left to the defaults, the exception is the number of threads.

Varnish will use one thread for each session and the number of threads you let Varnish use is directly proportional to how many requests Varnish can serve concurrently.

The available parameters directly related to threads are:

Parameter	Default value
<code>thread_pool_add_delay</code>	2 [milliseconds]
<code>thread_pool_add_threshold</code>	2 [requests]
<code>thread_pool_fail_delay</code>	200 [milliseconds]
<code>thread_pool_max</code>	500 [threads]
<code>thread_pool_min</code>	5 [threads]
<code>thread_pool_purge_delay</code>	1000 [milliseconds]
<code>thread_pool_stack</code>	65536 [bytes]
<code>thread_pool_timeout</code>	300 [seconds]
<code>thread_pools</code>	2 [pools]
<code>thread_stats_rate</code>	10 [requests]

Among these, `thread_pool_min` and `thread_pool_max` are most important. The `thread_pools` parameter is also of some importance, but mainly because it is used to calculate the final number of threads.

Varnish operates with multiple pools of threads. When a connection is accepted, the connection is delegated to one of these thread pools. The thread pool will further delegate the connection to available thread if one is available, put the connection on a queue if there are no available threads or drop the connection if the queue is full. By default, Varnish uses 2 thread pools, and this has proven sufficient for even the most busy Varnish server.

For the sake of keeping things simple, the current best practice is to leave `thread_pools` at the default 2 [pools].



3.6.2 Number of threads

Varnish has the ability to spawn new worker threads on demand, and remove them once the load is reduced. This is mainly intended for traffic spikes. It's a better approach to try to always keep a few threads idle during regular traffic than it is to run on a minimum amount of threads and constantly spawn and destroy threads as demand changes. As long as you are on a 64-bit system, the cost of running a few hundred threads extra is very limited.

The `thread_pool_min` parameter defines how many threads will be running for each thread pool even when there is no load. `thread_pool_max` defines the maximum amount of threads that will be used per thread pool.

The defaults of a minimum of 5 [threads] and maximum 500 [threads] threads per thread pool and 2 [pools] will result in:

- At any given time, at least $5 \text{ [threads]} * 2 \text{ [pools]}$ worker threads will be running
- No more than $500 \text{ [threads]} * 2 \text{ [pools]}$ threads will run.

We rarely recommend running with more than 5000 threads. If you seem to need more than 5000 threads, it's very likely that there is something not quite right about your setup, and you should investigate elsewhere before you increase the maximum value.

For minimum, it's common to operate with 500 to 1000 threads minimum (total). You can observe if this is enough through `varnishstat`, by looking at the *N queued work requests* (`n_wrk_queued`) counter over time. It should be fairly static after startup.

3.6.3 Timing thread growth

Varnish can use several thousand threads, and has had this capability from the very beginning. Not all operating system kernels were prepared to deal with this, though, so the parameter `thread_pool_add_delay` was added which ensures that there is a small delay between each thread that spawns. As operating systems have matured, this has become less important and the default value of `thread_pool_add_delay` has been reduced dramatically, from 20ms to 2ms.

There are a few, less important parameters related to thread timing. The `thread_pool_timeout` is how long a thread is kept around when there is no work for it before it is removed. This only applies if you have more threads than the minimum, and is rarely changed.

Another less important parameter is the `thread_pool_fail_delay`, which defines how long to wait after the operating system denied us a new thread before we try again.



3.7 System parameters

As Varnish has matured, fewer and fewer parameters require tuning. The `sess_workspace` is one of the parameters that could still pose a problem.

- `sess_workspace` - incoming HTTP header workspace (from client)
- Common values range from the default of 65536 [bytes] to 10MB
- ESI typically requires exponential growth
- Remember: It's all virtual - not physical memory.

Workspaces are some of the things you can change with parameters. The session workspace is how much memory is allocated to each HTTP session for tasks like string manipulation of incoming headers. It is also used to modify the object returned from a web server before the precise size is allocated and the object is stored read-only.

Some times you may have to increase the session workspace to avoid running out of workspace.

As most of the parameters can be left unchanged, we will not go through all of them, but take a look at the `list param.show` gives you to get an impression of what they can do.



3.8 Timers

Parameter	Default	Description	Scope
<code>connect_timeout</code>	0.700000 [s]	OS/network latency	Backend
<code>first_byte_timeout</code>	60.000000 [s]	Page generation?	Backend
<code>between_bytes_timeout</code>	60.000000 [s]	Hiccoughs?	Backend
<code>send_timeout</code>	60 [seconds]	Client-in-tunnel	Client
<code>sess_timeout</code>	5 [seconds]	keep-alive timeout	Client
<code>cli_timeout</code>	10 [seconds]	Management thread->child	Management

The timeout-parameters are generally set to pretty good defaults, but you might have to adjust them for unusual applications. The connection timeout is tuned for a geographically close web server, and might have to be increased if your Varnish server and web server are not close.

Keep in mind that the session timeout affects how long sessions are kept around, which in turn affects file descriptors left open. It is not wise to increase the session timeout without taking this into consideration.

The `cli_timeout` is how long the management thread waits for the worker thread to reply before it assumes it is dead, kills it and starts it back up. The default value seems to do the trick for most users today.

Note

The `connect_timeout` is 0.700000 [s] by default. This is more than enough time for the typical setup where Varnish talks to a backend in the same server room - but it may be too short if Varnish is using a remote backend which may have more latency. If this is set too high, it will not let Varnish handle errors gracefully.

An other use-case for increasing `connect_timeout` occurs when virtual machines are involved in the stack, as they can increase the connection time significantly.



3.9 Exercise: Tune first_byte_timeout

1. Create a small CGI script in `/usr/lib/cgi-bin/test.cgi` containing:

```
#!/bin/sh
sleep 5
echo "Content-type: text/plain"
echo "Cache-control: max-age=0"
echo
echo "Hello world"
date
```

2. Make it executable.
3. Test that it works outside of Varnish.
4. Start Varnish, test that it works through Varnish.
5. Set `first_byte_timeout` to 2s.
6. Check that it doesn't work.



3.10 Exercise: Configure threading

While performing this exercise, watch the `n_wrk` counter in `varnishstat` to determine the number of threads that are running.

1. Start Varnish.
2. Change the `thread_pool_min` and `thread_pool_max` parameters to get 100 threads running at any given time, but never more than 400.
3. Make the changes work across restarts of Varnish.

Extra: Experiment with `thread_pool_add_delay` and `thread_pool_timeout` while watching `varnishstat` to see how thread creation and destruction is affected. Does `thread_pool_timeout` affect already running threads?

You can also try changing the `thread_pool_stack` variable to a low value. This will only affect new threads, but try to find out how low you can set it, and what happens if it's too low.

Note

It's not common to modify `thread_pool_stack`, `thread_pool_add_delay` or `thread_pool_timeout`. These extra assignments are for educational purposes, and not intended as an encouragement to change the values.



4 HTTP

This chapter is for the webdeveloper course only

This chapter covers:

- Protocol basics
- Requests and responses
- HTTP request/response control flow
- Statelessness and idempotence
- Cache related headers

HTTP is at the heart of Varnish, or rather the model HTTP represents.

This chapter will cover the basics of HTTP as a protocol, how it's used in the wild, and delve into caching as it applies to HTTP.



4.1 Protocol basics

- Hyper-Text Transfer Protocol, HTTP, is at the core of the web
- Specified by the IETF, the latest version (HTTP/1.1) is available from <http://tools.ietf.org/html/rfc2616>
- A request consists of a request method, headers and an optional request body.
- A response consists of a response status, headers and an optional response body.
- Multiple requests can be sent over a single connection, in serial.
- Clients will open multiple connections to fetch resources in parallel.

HTTP is a networking protocol for distributed systems. It is the foundation of data communication for the Web. The development of this standard is done by the IETF and the W3C. The latest version of the standard is HTTP/1.1.

A new version of HTTP called HTTP bis is under development, you can follow the work document at <http://datatracker.ietf.org/wg/httpbis/charter/>. Basically HTTP bis will be HTTP/1.1 with new features for example a better caching of web pages.



4.2 Requests

- Standard request methods are: *GET*, *POST*, *HEAD*, *OPTIONS*, *PUT*, *DELETE*, *TRACE*, or *CONNECT*.
- This is followed by a URI, e.g: */img/image.png* or */index.html*
- Usually followed by the HTTP version
- A new-line (CRLF), followed by an arbitrary amount of CRLF-separated headers (*Accept-Language*, *Cookie*, *Host*, *User-Agent*, etc).
- A single empty line, ending in CRLF.
- An optional message body, depending on the request method.

Each request has the same, strict and fairly simple pattern. A request method informs the web server what sort of request this is: Is the client trying to fetch a resource (*GET*), or update some data(*POST*)? Or just get the headers of a resource (*HEAD*)?

There are strict rules that apply to the request methods. For instance, a *GET* request can not contain a request body, but a *POST* request can.

Similarly, a web server can not attach a request body to a response to a *HEAD* body.



4.3 Request example

```
GET / HTTP/1.1
Host: localhost
User-Agent: Mozilla/5.0 (Macintosh; U; Intel Mac OS X 10.5; fr; rv:1.9.2.16) Gecko/20110319 Firefox/3.6.16
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: fr,fr-fr;q=0.8,en-us;q=0.5,en;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 115
Connection: keep-alive
Cache-Control: max-age=0
```

The above is a typical HTTP *GET* request for the / resource.

Note that the `Host`-header contains the hostname as seen by the browser. The above request was generated by entering <http://localhost/> in the browser. The browser automatically adds a number of headers. Some of these will vary depending on language settings, others will vary depending on whether the client has a cached copy of the page already, or if the client is doing a refresh or forced refresh.

Whether the server honors these headers will depend on both the server in question and the specific header.

The following is an example of a HTTP request using the *POST* method, which includes a request body:

```
POST /accounts/ServiceLoginAuth HTTP/1.1
Host: www.google.com
User-Agent: Mozilla/5.0 (Macintosh; U; Intel Mac OS X 10.5; fr; rv:1.9.2.16) Gecko/20110319 Firefox/3.6.16
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: fr,fr-fr;q=0.8,en-us;q=0.5,en;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 115
Connection: keep-alive
Referer: https://www.google.com/accounts/ServiceLogin
Cookie: GoogleAccountsLocale_session=en:[...]
Content-Type: application/x-www-form-urlencoded
Content-Length: 288

ltmpl=default[...]&signIn=Sign+in&asts=
```



4.4 Response

```
HTTP/1.1 200 OK
Cache-Control: max-age=150
Content-Length: 150

[data]
```

- A HTTP response contains the HTTP versions, response code(e.g: 200) and response message (e.g: OK).
- CRLF as line separator
- A number of headers
- Headers are terminated with a blank line.
- Optional response body

The HTTP response is similar to the request itself. The response code informs the browser both whether the request succeeded and what type of response this is. The response message is a text-representation of the same information, and is often ignored by the browser itself.

Examples of status codes are *200 OK*, *404 File Not Found*, *304 Not Modified* and so fort. They are all defined in the HTTP standard, and grouped into the following categories:

- 1xx: Informational - Request received, continuing process
- 2xx: Success - The action was successfully received, understood, and accepted
- 3xx: Redirection - Further action must be taken in order to complete the request
- 4xx: Client Error - The request contains bad syntax or cannot be fulfilled
- 5xx: Server Error - The server failed to fulfill an apparently valid request



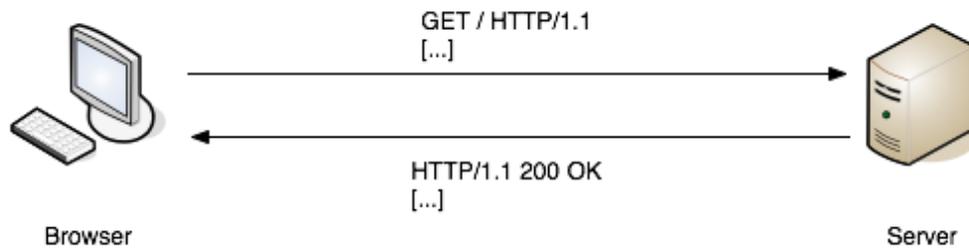
4.5 Response example

```
HTTP/1.1 200 OK
Server: Apache/2.2.14 (Ubuntu)
X-Powered-By: PHP/5.3.2-1ubuntu4.7
Cache-Control: public, max-age=86400
Last-Modified: Mon, 04 Apr 2011 04:13:41 +0000
Expires: Sun, 11 Mar 1984 12:00:00 GMT
Vary: Cookie,Accept-Encoding
ETag: "1301890421"
Content-Type: text/html; charset=utf-8
Content-Length: 23562
Date: Mon, 04 Apr 2011 09:02:26 GMT
X-Varnish: 1886109724 1886107902
Age: 17324
Via: 1.1 varnish
Connection: keep-alive

(data)
```



4.6 HTTP request/response control flow



The client sends an HTTP request to the server which returns an HTTP response with the message body.



4.7 Statelessness and idempotence

statelessness

HTTP is by definition a stateless protocol which means that in theory your browser has to reconnect to the server for every request. In practice there is a header called *Keep-Alive* you may use if you want to keep the connection open between the client (your browser) and the server.

idempotence

Idempotence means that an operation can be applied multiple times without changing the result. *GET* and *PUT* HTTP request are expected to be idempotent whereas *POST* requests are not. In other words, you can not cache *POST* HTTP responses.

For more discussion about idempotence <http://queue.acm.org/detail.cfm?id=2187821>.



4.8 Cache related headers

HTTP provides a list of headers dedicated to page caching and cache invalidation. The most important ones are :

- Expires
- Cache-Control
- Etag
- Last-Modified
- If-Modified-Since
- If-None-Match
- Vary
- Age



4.9 Exercise : Test various Cache headers

Before we talk about all the various cache headers and cache mechanisms, we will use *httpheadersexample.php* to experiment and get a sense of what it's all about.

Try both clicking the links twice, hitting refresh and forced refresh (usually done by hitting control-F5, depending on browser).

1. Try out the Expires-header and see how the browser and Varnish behave.
2. What happens when both Expires and Cache-Control is present?
3. Test the *If-Modified-Since* request too. Does the browser issue a request to Varnish? If the item was in cache, does Varnish query the web-server?
4. Try the *Vary*-test by using two different browsers at the same time.

When performing this exercise, try to see if you can spot the patterns. There are many levels of cache on the Web, and you have to think about more than just Varnish.

If it hasn't already, it's likely that browser cache will confuse you at least a few times through this course. When that happens, pull up varnishlog or another browser.



4.10 Expires

The *Expires response* header field gives the date/time after which the response is considered stale. A stale cache item will not be returned by any cache (proxy cache or client cache).

The syntax for this header is:

```
Expires: GMT formatted date
```

It is recommended not to define *Expires* too far in the future. Setting it to 1 year is usually enough.

Using *Expires* does not prevent the cached resource to be updated. If a resource is updated changing its name (by using a version number for instance) is possible.

Expires works best for any file that is part of your design like JavaScripts stylesheets or images.



4.11 Cache-Control

The *Cache-Control* header field specifies directives that **must** be applied by all caching mechanisms (from proxy cache to browser cache). *Cache-Control* accepts the following arguments (only the most relevant are described):

- *public*: The response may be cached by any cache.
- *no-store*: The response body **must not** be stored by any cache mechanism;
- *no-cache*: Authorizes a cache mechanism to store the response in its cache but it **must not** reuse it without validating it with the origin server first. In order to avoid any confusion with this argument think of it as a "store-but-do-no-serve-from-cache-without-revalidation" instruction.
- *max-age*: Specifies the period in seconds during which the cache will be considered fresh;
- *s-maxage*: Like *max-age* but it applies only to public caches;
- *must-revalidate*: Indicates that a stale cache item can not be serviced without revalidation with the origin server first;

Unlike *Expires*, *Cache-Control* is both a **request** and a **response** header, here is the list of arguments you may use for each context:

Argument	Request	Response
<i>no-cache</i>	X	X
<i>no-store</i>	X	X
<i>max-age</i>	X	X
<i>s-maxage</i>		X
<i>max-stale</i>	X	
<i>min-fresh</i>	X	
<i>no-transform</i>	X	X
<i>only-if-cached</i>	X	
<i>public</i>		X
<i>private</i>		X
<i>must-revalidate</i>		X
<i>proxy-revalidate</i>		X

Example of a *Cache-Control* header:

```
Cache-Control: public, must-revalidate, max-age=2592000
```



Note

As you might have noticed *Expires* and *Cache-Control* do more or less the same job, *Cache-Control* gives you more control though. There is a significant difference between these two headers:

- *Cache-Control* uses relative times in seconds, cf (s)max-age
- *Expires* always returns an absolute date

Note

Cache-Control **always** overrides Expires.

Note

By default, Varnish does not care about the Cache-Control request header. If you want to let users update the cache via a force refresh you need to do it yourself.



4.12 Last-Modified

The *Last-Modified* **response** header field indicates the date and time at which the origin server believes the variant was last modified. This headers may be used in conjunction with *If-Modified-Since* and *If-None-Match*.

Example of a *Last-Modified* header:

```
Last-Modified: Wed, 01 Sep 2004 13:24:52 GMT
```



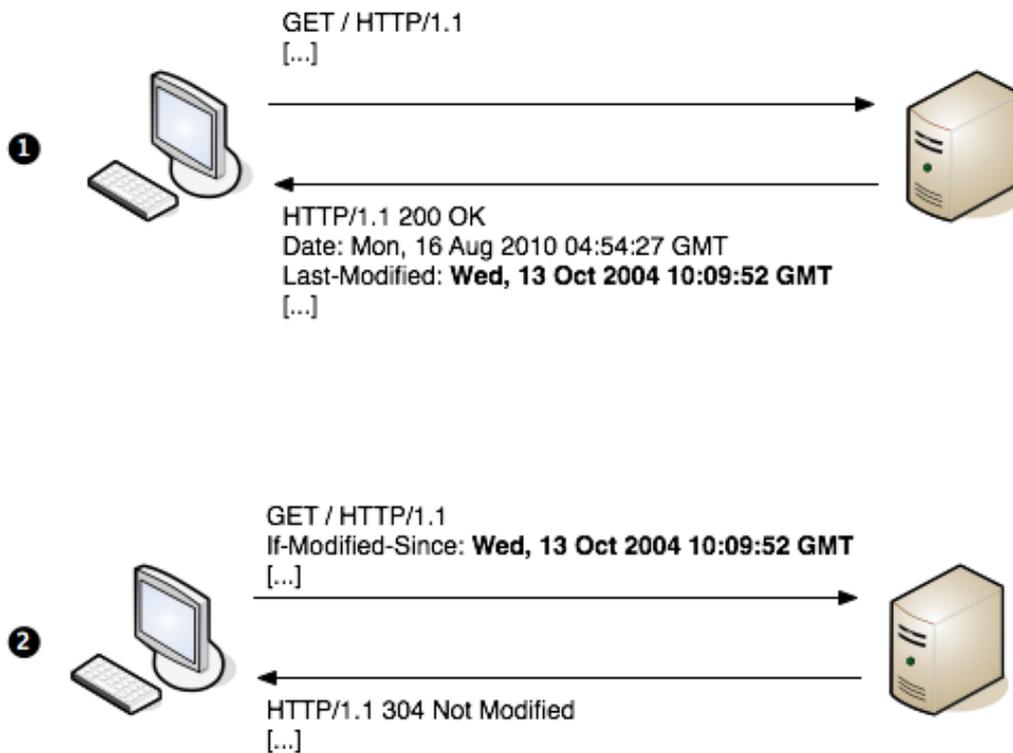
4.13 If-Modified-Since

The *If-Modified-Since* **request** header field is used with a method to make it conditional:

- **if** the requested variant has not been modified since the time specified in this field, an entity will not be returned from the server;
- **instead**, a 304 (not modified) response will be returned without any message-body.

Example of an *If-Modified-Since* header:

```
If-Modified-Since: Wed, 01 Sep 2004 13:24:52 GMT
```



4.14 If-None-Match

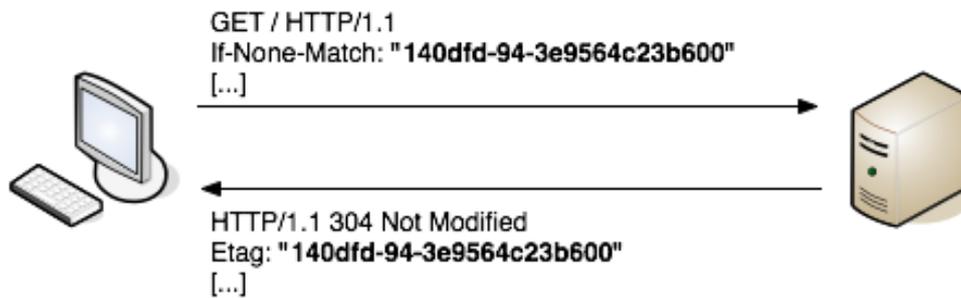
The *If-None-Match* **request** header field is used with a method to make it conditional.

A client that has one or more entities previously obtained from the resource can verify that none of those entities is current by including a list of their associated entity tags in the *If-None-Match* header field.

The purpose of this feature is to allow efficient updates of cached information with a minimum amount of transaction overhead. It is also used to prevent a method (e.g. PUT) from inadvertently modifying an existing resource when the client believes that the resource does not exist.

Example of an *If-None-Match* header :

```
If-None-Match: "1edec-3e3073913b100"
```



4.15 Etag

The *ETag* **response** header field provides the current value of the entity tag for the requested variant. The idea behind *Etag* is to provide a unique value for a resource's contents.

Example of an *Etag* header:

```
Etag: "1edec-3e3073913b100"
```



4.16 Pragma

The *Pragma request* header is a legacy header and should no longer be used. Some applications still send headers like `Pragma: no-cache` but this is for backwards compatibility reasons **only**.

Any proxy cache should treat `Pragma: no-cache` as `Cache-Control: no-cache`, and should not be seen as a reliable header especially when used as a response header.



4.17 Vary

The *Vary response* header indicates the response returned by the origin server may vary depending on headers received in the request.

The most common usage of *Vary* is to use `Vary: Accept-Encoding`, which tells caches (Varnish included) that the content might look different depending on the *Accept-Encoding*-header the client sends. In other words: The page can be delivered compressed or uncompressed depending on the client.

The *Vary*-header is one of the trickiest headers to deal with for a cache. A cache, like Varnish, does not necessarily understand the semantics of a header, or what part triggers different variants of a page.

As a result, using `Vary: User-Agent` for instance tells a cache that for ANY change in the *User-Agent*-header, the content *might* look different. Since there are probably thousands of *User-Agent* strings out there, this means you will drastically reduce the efficiency of any cache method.

An other example is using `Vary: Cookie` which is actually not a bad idea. Unfortunately, you can't issue `Vary: Cookie`(but only THESE cookies: ...). And since a client will send you a great deal of cookies, this means that just using `Vary: Cookie` is not necessarily sufficient. We will discuss this further in the Content Composition chapter.

Note

From Varnish version 3, Varnish handles *Accept-Encoding* and `Vary: Accept-Encoding` for you. This is because Varnish 3 has support for gzip compression. In Varnish 2 it was necessary to normalize the *Accept-Encoding*-header, but this is redundant in Varnish 3.



4.18 Age

- A cache server can send an additional response header, *Age*, to indicate the age of the response.
- Varnish (and other caches) does this.
- Browsers (and Varnish) will use the *Age*-header to determine how long to cache.
- E.g: for a *max-age*-based equation: $\text{cache duration} = \text{max-age} - \text{Age}$
- If you allow Varnish to cache for a long time, the *Age*-header could effectively disallow client-side caches.

Consider what happens if you let Varnish cache content for a week, because you can easily invalidate the cache Varnish keeps. If you do not change the *Age*-header, Varnish will happily inform clients that the content is, for example, two days old, and that the maximum age should be no more than fifteen minutes.

Browsers will obey this. They will use the reply, but they will also realize that it has exceeded its *max-age*, so they will not cache it.

Varnish will do the same, if your web-server emits an *Age*-header (or if you put one Varnish-server in front of another).

We will see in later chapters how we can handle this in Varnish.



4.19 Header availability summary

The table below lists HTTP headers seen above and whether they are a request header or a response one.

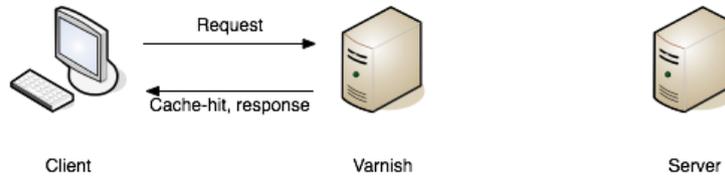
Header	Request	Response
Expires		X
Cache-Control	X	X
Last-Modified		X
If-Modified-Since	X	
If-None-Match	X	
Etag		X
Pragma	X	X
Vary		X
Age		X



4.20 Cache-hit and misses

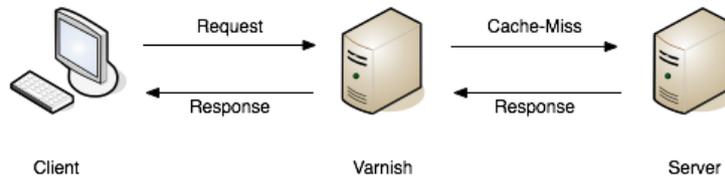
cache-hit

There is a cache-hit when Varnish returns a page from its cache instead of forwarding the request to the origin server.



cache-miss

There is a cache-miss when Varnish has to forward the request to the origin server so the page can be serviced.



4.21 Exercise: Use *article.php* to test Age

1. Modify the *article.php*-script to send an Age header that says 30 and `Cache-Control: max-age=60`.
2. Watch `varnishlog`.
3. Send a request to Varnish for *article.php*. See what Age-Header Varnish replies with.
4. Is the Age-header an accurate method to determine if Varnish made a cache hit or not?
5. How long does Varnish cache the reply? How long would a browser cache it?

Also consider how you would avoid issues like this to begin with. We do not yet know how to modify Varnish' response headers, but hopefully you will understand why you may need to do that.

Varnish is not the only part of your web-stack that parses and honors cache-related headers. The primary consumer of such headers are the web browsers, and there might also be other caches along the way which you do not control, like a company-wide proxy server.

By using *s-maxage* instead of *max-age* we limit the number of consumers to cache servers, but even *s-maxage* will be used by caching proxies which you do not control.

In the next few chapters, you will learn how to modify the response headers Varnish sends. That way, your web-server can emit response headers that are only seen and used by Varnish.



5 VCL Basics

- VCL as a state engine
- Basic syntax
- VCL_recv and VCL_fetch
- Regular expressions

The Varnish Configuration Language allows you to define your caching policy. You write VCL code which Varnish will parse, translate to C code, compile and link to.

The following chapter focuses on the most important tasks you will do in VCL. Varnish has a number of states that you can hook into with VCL, but if you master the `vcl_fetch` and `vcl_recv` methods, you will have covered the vast majority of the actual work you need to do.

VCL is often described as domain specific or a state engine. The domain specific part of it is that some data is only available in certain states. For example: You can not access response headers before you've actually started working on a response.



5.1 The VCL State Engine

- Each request is processed separately.
- Each request is independent of any others going on at the same time, previously or later.
- States are related, but isolated.
- `return(x)`; exits one state and instructs Varnish to proceed to the next state.
- Default VCL code is always present, appended below your own VCL.

Before we begin looking at VCL code, it's worth trying to understand the fundamental concepts behind VCL.

When Varnish processes a request, it starts by parsing the request itself, separating the request method from headers, verifying that it's a valid HTTP request and so on. When this basic parsing has completed, the very first policy decisions can be done: Should Varnish even attempt to find this resource in the cache? This decision is left to VCL, more specifically the `vcl_recv` method.

If you do not provide any `vcl_recv` function, the default VCL function for `vcl_recv` is executed. But even if you do specify your own `vcl_recv` function, the default is still present. Whether it is executed or not depends on whether your own VCL code terminates that specific state or not.

Tip

It is strongly advised to let the default VCL run whenever possible. It is designed with safety in mind, which often means it'll handle any flaws in your VCL in a reasonable manner. It may not cache as much, but often it's better to not cache some content instead of delivering the wrong content to the wrong user.

There are exceptions, of course, but if you can not understand why the default VCL does not let you cache some content, it is almost always worth it to investigate why instead of overriding it.



5.2 Syntax

- `//`, `#` and `/* foo */` for comments
- `sub $name` functions
- No loops, limited variables
- Terminating statements, no return values
- Domain-specific
- Add as little or as much as you want

If you have worked with a programming language or two before, the basic syntax of Varnish should be reasonably straight forward. It is inspired mainly by C and Perl.

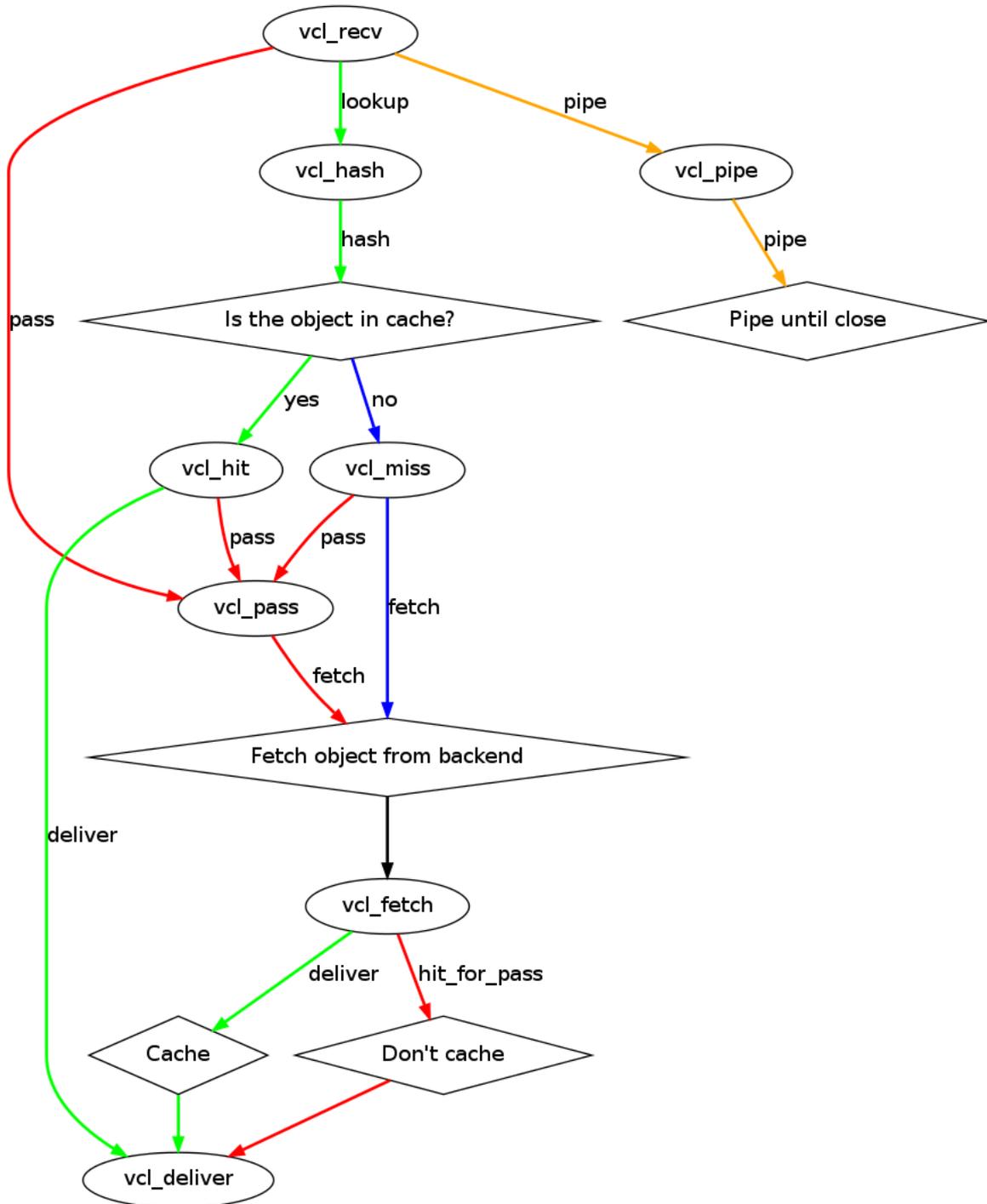
The functions of VCL are not true functions in the sense that they accept variables and return values. To send data inside of VCL, you will have to hide it inside of HTTP headers.

The "return" statement of VCL returns control from the VCL state engine to Varnish. If you define your own function and call it from one of the default functions, typing "return(foo)" will not return execution from your custom function to the default function, but return execution from VCL to Varnish. That is why we say that VCL has terminating statements, not traditional return values.

For each domain, you can return control to Varnish using one or more different return values. These return statements tell Varnish what to do next. Examples include "look this up in cache", "do not look this up in the cache" and "generate an error message".



5.3 VCL - request flow



5.3.1 Detailed request flow



5.4 VCL - functions

- `regsub(str, regex, sub)`
- `regsuball(str, regex, sub)`
- `ban_url(regex)`
- `ban(expression)`
- `purge;`
- `return(restart)`
- `return()`
- `hash_data()`

VCL offers a handful of simple functions that allow you to modify strings, add bans, restart the VCL state engine and return control from the VCL Run Time (VRT) environment to Varnish.

You will get to test all of these in detail, so the description is brief.

`regsub()` and `regsuball()` has the same syntax and does the same thing: They both take a string as input, search it with a regular expression and replace it with another string. The difference between `regsub()` and `regsuball()` is that the latter changes all occurrences while the former only affects the first match.

`ban_url` is one of the original ban functions provided, and are generally not used much. The more flexible `ban()` function can perform the same task. `ban_url(foo)` is the equivalent of `ban("req.url ~ " foo)`: Add a URL, host name excluded, to the ban list. We will go through purging in detail in later chapters.

`return(restart)` offers a way to re-run the VCL logic, starting at `vcl_recv`. All changes made up until that point are kept and the `req.restarts` variable is incremented. The `max_restarts` parameter defines the maximum number of restarts that can be issued in VCL before an error is triggered, thus avoiding infinite looping.

`return()` is used when execution of a VCL domain (for example `vcl_recv`) is completed and control is returned to Varnish with a single instruction as to what should happen next. Return values are *lookup*, *pass*, *pipe*, *hit_for_pass*, *fetch*, *deliver* and *hash*, but only a limited number of them are available in each VCL domain.

Warning

`ban_url()` uses a regular expression instead of actual string matching. It will be removed in Varnish 4. You should use `ban()` instead.



5.5 VCL - vcl_recv

- Normalize client-input
- Pick a backend web server
- Re-write client-data for web applications
- Decide caching policy based on client-input
- Access control
- Security barriers
- Fixing mistakes (e.g: `index.htmlm -> index.html`)

`vcl_recv` is the first VCL function executed, right after Varnish has decoded the request into its basic data structure. It has four main uses:

1. Modifying the client data to reduce cache diversity. E.g., removing any leading "www." in a URL.
2. Deciding caching policy based on client data. E.g., Not caching POST requests, only caching specific URLs, etc
3. Executing re-write rules needed for specific web applications.
4. Deciding which Web server to use.

In `vcl_recv` you can perform the following terminating statements:

pass the cache, executing the rest of the Varnish processing as normal, but not looking up the content in cache or storing it to cache.

pipe the request, telling Varnish to shuffle byte between the selected backend and the connected client without looking at the content. Because Varnish no longer tries to map the content to a request, any subsequent request sent over the same keep-alive connection will also be piped, and not appear in any log.

lookup the request in cache, possibly entering the data in cache if it is not already present.

error - Generate a synthetic response from Varnish. Typically an error message, redirect message or response to a health check from a load balancer.

It's also common to use `vcl_recv` to apply some security measures. Varnish is not a replacement for Intrusion Detection Systems, but can still be used to stop some typical attacks early. Simple access control lists can be applied in `vcl_recv` too. For further discussion about security in VCL, take a look at the Security.vcl project, found at <https://github.com/comotion/security.vcl>.



5.6 Default: vcl_recv

```
sub vcl_recv {
    if (req.restarts == 0) {
        if (req.http.x-forwarded-for) {
            set req.http.X-Forwarded-For =
                req.http.X-Forwarded-For + ", " + client.ip;
        } else {
            set req.http.X-Forwarded-For = client.ip;
        }
    }
    if (req.request != "GET" &&
        req.request != "HEAD" &&
        req.request != "PUT" &&
        req.request != "POST" &&
        req.request != "TRACE" &&
        req.request != "OPTIONS" &&
        req.request != "DELETE") {
        /* Non-RFC2616 or CONNECT which is weird. */
        return (pipe);
    }
    if (req.request != "GET" && req.request != "HEAD") {
        /* We only deal with GET and HEAD by default */
        return (pass);
    }
    if (req.http.Authorization || req.http.Cookie) {
        /* Not cacheable by default */
        return (pass);
    }
    return (lookup);
}
```

The default VCL for `vcl_recv` is designed to ensure a safe caching policy even with no modifications in VCL. It has two main uses:

1. Only handle recognized HTTP methods and cache GET and HEAD
2. Do not cache data that is likely to be user-specific.

It is executed right after any user-specified VCL, and is always present. You can not remove it. However, if you terminate the `vcl_recv` function using one of the terminating statements (`pass`, `pipe`, `lookup`, `error`), the default VCL will not execute, as control is handed back from the VRT (VCL Run-Time) to Varnish.

Most of the logic in the default VCL is needed for a well-behaving Varnish server, and care should be taken when `vcl_recv` is terminated before reaching the default VCL. Consider either replicating all the logic in your own VCL, or letting Varnish fall through to the default VCL.



5.7 Example: Basic Device Detection

One way of serving different content for mobile devices and desktop browsers is to run some simple parsing on the *User-Agent* header to create your own custom-header for mobile devices:

```
sub vcl_recv {
    if (req.http.User-Agent ~ "iPad" ||
        req.http.User-Agent ~ "iPhone" ||
        req.http.User-Agent ~ "Android") {
        set req.http.X-Device = "mobile";
    } else {
        set req.http.X-Device = "desktop";
    }
}
```

You can read more about different types of device detection at <https://www.varnish-cache.org/docs/trunk/users-guide/devicedetection.html>

This simple VCL will create a request header called *X-Device* which will contain either `mobile` or `desktop`. The Web server can then use this header to determine what page to serve, and inform Varnish about it through `Vary: X-Device`.

It might be tempting to just send `Vary: User-Agent`, but that would either require you to normalize the *User-Agent* header itself and losing the detailed information on the browser, or it would drastically inflate the cache size by keeping possibly hundreds of different variants for each object just because there are tiny variations of the *User-Agent* header.

For more information on the *Vary*-header, see the HTTP chapter.

Note

If you do use `Vary: X-Device`, you might want to send `Vary: User-Agent` to the users *after* Varnish has used it. Otherwise, intermediary caches will not know that the page looks different for different devices.



5.8 Exercise: Rewrite URLs and Host headers

1. Copy the original *Host*-header (`req.http.Host`) and URL (`req.url`) to two new request header of your choice. E.g: `req.http.x-host` and `req.http.x-url`.
2. Ensure that `www.example.com` and `example.com` are cached as one, using `regsub()`.
3. Rewrite all URLs under `http://sport.example.com` to `http://example.com/sport/`. For example: `http://sport.example.com/article1.html` to `http://example.com/sport/article1.html`.
4. Use `varnishlog` to verify the result.

Extra: Make sure `/` and `/index.html` is cached as one object. How can you verify that it is, without changing the content?

Extra 2: Make the redirection work for any domain with `sport.` at the front. E.g: `sport.example.com`, `sport.foobar.example.net`, `sport.blatti`, etc.

The syntax for `regsub()` is `regsub(<string>, <regex>, <replacement>)`; *string* is the input string, in this case, `req.http.host`. *regex* is the regular expression matching whatever content you need to change. `^www.` matches a string that begins (^) with `www` followed by a literal dot. *replacement* is what you desire to change it with, `""` can be used to remove it.

To write a header, use `set req.http.headername = "value";` or `set req.http.headername = regsub(...);`

To verify the result, you can use `varnishlog`, or `lwp-request`. Example command:

```
GET -H "Host: www.example.com" -USsed http://localhost/
```

You can use `if ()` to perform a regular expression if-test, or a plain string test. In the above exercise, both are valid. E.g.:

```
if (req.http.host ~ "^sport\.example\.com$") {
```

is equivalent with:

```
if (req.http.host == "sport.example.com") {
```

It is slightly faster to use `==` to perform a string comparison instead of a regular expression, but negligible.

Tip

You do not need to use `regsub()` on the host header for this exercise unless you want it to apply for all instances of `sport.<some domain>`. You will, however, need it to prepend `/sport` to the `req.url`. Remember, you can match just the beginning of the line with `regsub(input, "^", replacement)`



5.9 Solution: Rewrite URLs and Host headers

```
sub vcl_recv {
    set req.http.x-host = req.http.host;
    set req.http.x-url = req.url;
    set req.http.host = regsub(req.http.host, "^www\.","");

    if (req.http.host == "sport.example.com") {
        set req.http.host = "example.com";
        set req.url = regsub(req.url, "^", "/sport");
    }

    // Or:

    if (req.http.host ~ "^sport\.") {
        set req.http.host = regsub(req.http.host,"^sport\.","");
        set req.url = regsub(req.url, "^", "/sport");
    }
}
```

Note how both are valid.



5.10 VCL - vcl_fetch

- Sanitize server-response
- Override cache duration

The `vcl_fetch` function is the backend-counterpart to `vcl_recv`. In `vcl_recv` you can use information provided by the client to decide on caching policy, while you use information provided by the server to further decide on a caching policy in `vcl_fetch`.

If you chose to *pass* the request in an earlier VCL function (e.g.: `vcl_recv`), you will still execute the logic of `vcl_fetch`, but the object will not enter the cache even if you supply a cache time.

You have multiple tools available in `vcl_fetch`. First and foremost you have the `beresp.ttl` variable, which defines how long an object is kept.

Warning

If the request was not passed *before* reaching `vcl_fetch`, the `beresp.ttl` is still used even when you perform a `hit_for_pass` in `vcl_fetch`. This is an important detail that is important to remember: When you perform a `pass` in `vcl_fetch` *you cache the decision you made*. In other words: If `beresp.ttl` is 10 hours and you issue a `pass`, an object will be entered into the cache and remain there for 10 hours, telling Varnish not to cache. If you decide not to cache a page that returns a "500 Internal Server Error", for example, this is critically important, as a temporary glitch on a page can cause it to not be cached for a potentially long time.

Always set `beresp.ttl` when you issue a `pass` in `vcl_fetch`.

Returning `deliver` in `vcl_fetch` tells Varnish to cache, if possible. Returning `hit_for_pass` tells it not to cache, but does *not* run the `vcl_pass` function of VCL for this specific client. The next client asking for the same resource will hit the `hitpass`-object and go through `vcl_pass`.

Typical tasks performed in `vcl_fetch` include:

- Overriding cache time for certain URLs
- Stripping Set-Cookie headers that are not needed
- Stripping bugged Vary headers
- Adding helper-headers to the object for use in banning (more information in later chapters)
- Applying other caching policies



5.11 Default: vcl_fetch

```
sub vcl_fetch {
    if (beresp.ttl <= 0s ||
        beresp.http.Set-Cookie ||
        beresp.http.Vary == "*") {
        /*
         * Mark as "Hit-For-Pass" for the next 2 minutes
         */
        set beresp.ttl = 120 s;
        return (hit_for_pass);
    }
    return (deliver);
}
```

The default VCL for `vcl_fetch` is designed to avoid caching anything with a set-cookie header. There are very few situations where caching content with a set-cookie header is desirable.



5.12 The initial value of `beresp.ttl`

Before Varnish runs `vcl_fetch`, the `beresp.ttl` variable has already been set to a value. It will use the first value it finds among:

- The `s-maxage` variable in the `Cache-Control` response header
- The `max-age` variable in the `Cache-Control` response header
- The `Expires` response header
- The `default_ttl` parameter.

Only the following status codes will be cached by default:

- 200: OK
- 203: Non-Authoritative Information
- 300: Multiple Choices
- 301: Moved Permanently
- 302: Moved Temporarily
- 307: Temporary Redirect
- 410: Gone
- 404: Not Found

You can still cache other status codes, but you will have to set the `beresp.ttl` to a positive value in `vcl_fetch` yourself.

Since all this is done before `vcl_fetch` is executed, you can modify the `Cache-Control` headers without affecting `beresp.ttl`, and vice versa.

A sensible approach is to use the `s-maxage` variable in the `Cache-Control` header to instruct Varnish to cache, then have Varnish remove that variable before sending it to clients using `regsub()` in `vcl_fetch`. That way, you can safely set `max-age` to what cache duration the clients should use and `s-maxage` for Varnish without affecting intermediary caches.

Warning

Varnish, browsers and intermediary will parse the `Age` response header. If you stack multiple Varnish servers in front of each other, this means that setting `s-maxage=300` will mean that the object really will be cached for only 300 seconds throughout all Varnish servers.

On the other hand, if your web server sends `Cache-Control: max-age=300, s-maxage=3600` and you do not remove the `Age` response header, Varnish will send an `Age`-header that exceeds the `max-age` of the objects, which will cause browsers to not cache the content.



5.13 Example: Enforce caching of .jpg urls for 60 seconds

```
sub vcl_fetch {
    if (req.url ~ "\.jpg$") {
        set beresp.ttl = 60s;
    }
}
```

The above example is typical for a site migrating to Varnish. Setting `beresp.ttl` ensures it's cached.

Keep in mind that the default VCL will still be executed, which means that an image with a Set-Cookie header will not be cached.



5.14 Example: Cache .jpg for 60 only if s-maxage isn't present

```
sub vcl_fetch {
    if (beresp.http.cache-control !~ "s-maxage" && req.url ~ "\.jpg$") {
        set beresp.ttl = 60s;
    }
}
```

The Cache-Control header can contain a number of headers. Varnish evaluates it and looks for s-maxage and max-age. It will set the TTL to the value of s-maxage if found. If s-maxage isn't found, it will use max-age. If neither exist, it will use the Expires header to set the ttl. If none of those headers exist, it will use the default TTL.

This is done before `vcl_fetch` is executed and the process can be seen by looking at the TTL tag of `varnishlog`.

The purpose of the above example is to allow a gradual migration to using a backend-controlled caching policy. If the backend supplies s-maxage, it will be used, but if it is missing, a forced TTL is set.



5.15 Exercise: Avoid caching a page

1. Write a VCL which avoids caching the index page at all. It should cover both accessing `/` and `/index.html`
2. Write a VCL that makes Varnish honor the following headers:

```
Cache-Control: no-cache  
Cache-Control: private  
Pragma: no-cache
```

When trying this out, remember that Varnish keeps the *Host*-header in `req.http.host` and the part after the hostname in `req.url`.

For `http://www.example.com/index.html`, the `http://` part is not seen by Varnish at all, but `req.http.host` will have the value of `www.example.com` and `req.url` the value of `/index.html`. Note how the leading `/` is included in `req.url`.

Varnish only obeys the first header it finds of "s-maxage" in Cache-Control, "max-age" in Cache-Control or the Expire header. However, it is often necessary to check the values of other headers too - `vcl_fetch` is the place to do that.



5.16 Solution: Avoid caching a page

```
sub vcl_recv {
    if (req.url ~ "^/index\.html" ||
        req.url ~ "^/$") { return(pass); }
}
// Or:
sub vcl_fetch {
    if (req.url ~ "^/index\.html" ||
        req.url ~ "^/$") { return(hit_for_pass); }
}

// Second part of exercise
sub vcl_fetch {
    if (beresp.http.cache-control ~ "(no-cache|private)" ||
        beresp.http.pragma ~ "no-cache") {
        set beresp.ttl = 0s;
    }
}
```

The above examples are both valid.

It is usually most convenient to do as much as possible in `vcl_recv`, and this is no exception. Even though using `pass` in `vcl_fetch` is reasonable, it creates a `hitpass` object, which can create unnecessary complexity. Whenever you do use `pass` in `vcl_fetch`, you should also make it a habit to set the `beresp.ttl` to a short duration, to avoid accidentally adding a `hitpass` object that prevents caching for a long time.



5.17 Exercise: Either use s-maxage or set ttl by file type

Write a VCL that:

- Uses `Cache-Control: s-maxage` where present
- Caches `.jpg` for 30 seconds if `s-maxage` isn't present
- Caches `.html` for 10 seconds if `s-maxage` isn't present
- Removes the `Set-Cookie` header if `s-maxage` OR the above rules indicates that Varnish should cache.

Tip

Try solving each part of the exercise by itself first. Most somewhat complex VCL tasks are easily solved when you divide the tasks into smaller bits and solve them individually.

Note

Varnish automatically reads `s-maxage` for you, so you only need to check if it is there or not - if it's present, Varnish has already used it to set `beresp.ttl`.



5.18 Solution: Either use s-maxage or set ttl by file type

```
sub vcl_fetch {
    if (beresp.http.cache-control !~ "s-maxage") {
        if (req.url ~ "\.jpg(\?|$)") {
            set beresp.ttl = 30s;
            unset beresp.http.Set-Cookie;
        }
        if (req.url ~ "\.html(\?|$)") {
            set beresp.ttl = 10s;
            unset beresp.http.Set-Cookie;
        }
    } else {
        if (beresp.ttl > 0s) {
            unset beresp.http.Set-Cookie;
        }
    }
}
```

There are many ways to solve this exercise, and this solution is only one of them. The first part checks that s-maxage is /not/ present, then handles .jpg and .html files - including cookie removal. The second part checks if s-maxage caused Varnish to set a positive ttl and consider it cacheable.



5.19 Summary of VCL - Part 1

- VCL provides a state machine for controlling Varnish.
- Each request is handled independently.
- Building a VCL file is done one line at a time.

VCL is all about policy. By providing a state machine which you can hook into, VCL allows you to affect the handling of any single request almost anywhere in the execution chain.

This provides both the pros and cons of any other programming language. There isn't going to be any complete reference guide to how you can deal with every possible scenario in VCL, but on the other hand, if you master the basics of VCL you can solve complex problems that nobody has thought about before. And you can usually do it without requiring too many different sources of documentation.

Whenever you are working on VCL, you should think of what that exact line you are writing has to do. The best VCL is built by having many independent sections that don't interfere with each other more than they have to.

This is made easier by the fact that VCL also has a default - which is always present. If you just need to modify one little thing in `vcl_recv`, you can do just that. You don't have to copy the default VCL, because it will be executed after your own - assuming you don't have any *return* statements.



6 VCL functions

- Start off with a cheat-sheet for variables
- Go through the remaining vcl functions: hash, pipe, miss, pass, hit, error and deliver.
- Add some "features" with VCL.

The following chapter will cover the parts of VCL where you typically venture to customize the behavior of Varnish and not define caching policy.

These functions can be used to add custom headers, change the appearance of the Varnish error message, add HTTP redirect features in Varnish, purge content and define what parts of a cached object is unique.

After this chapter, you should know what all the VCL functions can be used for, and you'll be ready to dive into more advanced features of Varnish and VCL.



6.1 Variable availability in VCL

Variable	recv	fetch	pass	miss	hit	error	deliver	pipe	hash
req.*	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
bereq.*		R/W	R/W	R/W				R/W	
obj.hits					R		R		
obj.ttl					R/W	R/W			
obj.grace					R/W				
obj.*					R	R/W			
beresp.*		R/W							
resp.*						R/W	R/W		

The above is a map of the most important variables and where you can read (R) from them and write (W) to them.

Some variables are left out: `client.*` and `server.*` are by and large accessible everywhere, as is the `now` variable.

Remember that changes made to `beresp` are stored in `obj` afterwards. And the `resp.*` variables are copies of what's about to be returned - possibly of `obj`. A change to `beresp` will, in other words, affect future `obj.*` and `resp.*` variables. Similar semantics apply to `req.*` and `bereq.*`. `bereq.*` is the "backend request" as created from the original request. It may differ slightly - Varnish can convert HEAD requests to GET for example.

Note

Many of these variables will be self-explaining during while you're working through these exercises, but we'll explain all of them towards the end of the chapter to make sure there's no confusion.



6.2 VCL - vcl_hash

- Defines what is unique about a request.
- Executed directly after `vcl_recv`

```
sub vcl_hash {
    hash_data(req.url);
    if (req.http.host) {
        hash_data(req.http.host);
    } else {
        hash_data(server.ip);
    }
    return (hash);
}
```

`vcl_hash` defines the hash key to be used for a cached object. Or in other words: What separates one cached object from the next.

One usage of `vcl_hash` could be to add a user-name in the cache hash to cache user-specific data. However, be warned that caching user-data should only be done cautiously. A better alternative might be to cache differently based on whether a user is logged in or not, but not necessarily what user it is.

The default VCL for `vcl_hash` adds the hostname (or IP) and the URL to the cache hash.

Note

The handling of the *Vary*-header is separate from the cache hash.



6.3 VCL - vcl_hit

- Right after an object has been found (hit) in the cache
- You can change the TTL or issue `purge`;
- Often used to throw out an old object

```
sub vcl_hit {  
    return (deliver);  
}
```



6.4 VCL - vcl_miss

- Right after an object was looked up and not found in cache
- Mostly used to issue `purge;`
- Can also be used to modify backend request headers

```
sub vcl_miss {  
    return (fetch);  
}
```

The subroutines `vcl_hit` and `vcl_miss` are closely related. It's rare that you can use them, and when you do, it's typically related to internal Varnish tricks - not debug-feedback or backend modification.

One example is using `purge;` to invalidate an object (more on this later), another is to rewrite a backend request when you want the ESI fragments to get the unmodified data.

You can also modify the backend request headers in `vcl_miss`. This is very uncommon, as you've likely done this in `vcl_recv` already. However, if you do not wish to send an *X-Varnish* header to the backend server, you need to remove it in `vcl_miss` and `vcl_pass` using `unset bereq.http.x-varnish;`



6.5 VCI - vcl_pass

- Run after a pass in `vcl_recv` OR after a lookup that returned a hitpass
- Not run after `vcl_fetch`.

```
sub vcl_pass {  
    return (pass);  
}
```

The `vcl_pass` function belongs in the same group as `vcl_hit` and `vcl_miss`. It is run right after either a cache lookup or `vcl_recv` determined that this isn't a cached item and it's not going to be cached.

The usefulness of `vcl_pass` is limited, but it typically serves as an important catch-all for features you've implemented in `vcl_hit` and `vcl_miss`. The prime example is the PURGE method, where you want to avoid sending a PURGE request to a backend.



6.6 VCL - vcl_deliver

- Common last exit point for all (except `vcl_pipe`) code paths
- Often used to add and remove debug-headers

```
sub vcl_deliver {  
    return (deliver);  
}
```

While the `vcl_deliver` function is simple, it is also very useful for modifying the output of Varnish. If you need to remove a header, or add one that isn't supposed to be stored in the cache, `vcl_deliver` is the place to do it.

The main building blocks of `vcl_deliver` are:

`resp.http.*`

Headers that will be sent to the client. They can be set and unset.

`resp.status`

The status code (200, 404, 503, etc).

`resp.response`

The response message ("OK", "File not found", "Service Unavailable").

`obj.hits`

The number of hits a cached object has made. This can be evaluated and sued as a string to easily reveal if a request was a cache hit or miss.

`req.restarts`

The number of restarts issued in VCL - 0 if none were made.



6.7 VCL - vcl_error

- Used to generate content from within Varnish, without talking to a web server
- Error messages go here by default
- Other use cases: Redirecting users (301/302 Redirects)

```
sub vcl_error {
    set obj.http.Content-Type = "text/html; charset=utf-8";
    set obj.http.Retry-After = "5";
    synthetic {"
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html>
  <head>
    <title>} + obj.status + " " + obj.response + {"</title>
  </head>
  <body>
    <h1>Error "} + obj.status + " " + obj.response + {"</h1>
    <p>} + obj.response + {"</p>
    <h3>Guru Meditation:</h3>
    <p>XID: "} + req.xid + {"</p>
    <hr>
    <p>Varnish cache server</p>
  </body>
</html>
"};
    return (deliver);
}
```

Note

Note how you can use {" and "} to make multi-line strings. This is not limited to synthetic, but can be used anywhere.



6.8 Example: Redirecting users with vcl_error

```
sub vcl_recv {
    if (req.http.host == "www.example.com") {
        set req.http.Location = "http://example.com" + req.url;
        error 750 "Permanently moved";
    }
}

sub vcl_error {
    if (obj.status == 750) {
        set obj.http.location = req.http.Location;
        set obj.status = 301;
        return (deliver);
    }
}
```

Redirecting with VCL is fairly easy - and fast. If you know a pattern, it's even easier.

Basic redirects in HTTP work by having the server return either 301 "Permanently moved" or 302 "Found", with a Location header telling the web browser where to look. The 301 can affect how browser prioritize history and how search engines treat the content. 302 are more temporary and will not affect search engines as greatly.

The above example illustrates how you can use Varnish to generate meta-content.



6.9 Exercise: Modify the error message and headers

- Make the default error message more friendly.
- Add a header saying either HIT or MISS
- "Rename" the Age header to X-Age.



6.10 Solution: Modify the error message and headers

```
sub vcl_error {
    synthetic "<html><body><!-- Blank page must mean it's a browser issue! --></body></html>";
    set obj.status = 200;
    return (deliver);
}

sub vcl_deliver {
    set resp.http.X-Age = resp.http.Age;
    unset resp.http.Age;

    if (obj.hits > 0) {
        set resp.http.X-Cache = "HIT";
    } else {
        set resp.http.X-Cache = "MISS";
    }
}
```

The solution doesn't use the "long-string" syntax that the default uses, but regular strings. This is all up to you.

Note

It's safer to make sure a variable has a sensible value before using it to make a string. That's why it's better to always check that `obj.hits > 0` (and not just `!= 0`) before you try using it. While there are no known bugs with `obj.hits` at the moment, string-conversion has been an area where there have been some bugs in the past when the variable to be converted had an unexpected value (for example if you tried using `obj.hits` after a pass in `vcl_recv`).

This applies to all variables - and all languages for that matter



7 Cache invalidation

- Explicit invalidation of cache
- `purge;` removes all variants of an object from cache, freeing up memory
- `set req.hash_always_miss = true;` can refresh content explicitly
- `ban();` can be used to invalidate objects based on regular expressions, but does not necessarily free up memory any time soon.
- Which to use when?
- What about this ban lurker?
- `obj.ttl = 0s;` is obsolete.

Whenever you deal with a cache, you will eventually have to deal with the challenge of cache invalidation, or refreshing content. There are many motives behind such a task, and Varnish addresses the problem in several slightly different ways.

Some questions you need to ask whenever the topic of cache invalidation comes up are:

- Am I invalidating one specific object, or many?
- Do I need to free up memory, or just replace the content?
- Does it take a long time to replace the content?
- Is this a regular task, or a one-off task?

The rest of the chapter will hopefully give you the knowledge you need to know which solution to pick when.



7.1 Naming confusion

- The course material uses Varnish 3-terminology if nothing else is stated.
- Varnish 3 uses the term *ban* and *banning* for what was known as *purge* and *purging* in Varnish 2. They are the same.
- Varnish 3 has a new function called `purge;` that did not exist in VCL in Varnish 2.
- `purge;` is a much improved way of doing what was in Varnish 2 done using `set obj.ttl = 0s;`.
- Sorry about the confusion!

With Varnish 3, an attempt was made to clean up some terminology. Unfortunately, this might have made things slightly worse, until people forget everything about Varnish 2.

The function called `purge()` in Varnish 2 is known as `ban()` in Varnish 3. This course material will use that terminology, but you are likely to run across material that refers to `purge()` where you should read it as `ban()`.

On top of that, Varnish 3 introduced the `purge;` function that's accessible in `vcl_hit` and `vcl_miss`. This replaces the usage of `set obj.ttl = 0s;`, which was common in Varnish 2, though the latter is still valid in Varnish 3.

All the terms will be discussed in more detail, of course. This is just a heads-up about possible naming confusion.



7.2 Removing a single object

- If you know exactly what to remove, use `purge;`.
- It must be used in both `vcl_hit` and `vcl_miss`
- Frees up memory, removes all `Vary:-`variants of the object.
- Leaves it to the next client to refresh the content
- Often combined with `return(restart);`

The `purge;` keyword is the simplest manner of removing content from the cache explicitly.

A resource can exist in multiple `Vary:-`variants. For example you could have a desktop version, a tablet version and a smartphone version of your site and use `Vary` in combination with device detection to store different variants of the same resource.

If you update your content you can use `purge;` to evict all variants of that content from the cache. This is done in both `vcl_hit` and `vcl_miss`. This is typically done by letting your content management system send a special HTTP request to Varnish. Since the content management system doesn't necessarily hit a variant of the object that is cached, you have to issue `purge;` in `vcl_miss` too. This ensures that all variants of that resource are evicted from cache.

The biggest down-side of using `purge;` is that you evict the content from cache before you know if Varnish can fetch a new copy from a web server. If the web server is down, Varnish has no old copy of the content.



7.3 Example: purge;

```
acl purgers {
    "127.0.0.1";
    "192.168.0.0"/24;
}

sub vcl_recv {
    if (req.request == "PURGE") {
        if (!client.ip ~ purgers) {
            error 405 "Method not allowed";
        }
        return (lookup);
    }
}

sub vcl_hit {
    if (req.request == "PURGE") {
        purge;
        error 200 "Purged";
    }
}

sub vcl_miss {
    if (req.request == "PURGE") {
        purge;
        error 404 "Not in cache";
    }
}

sub vcl_pass {
    if (req.request == "PURGE") {
        error 502 "PURGE on a passed object";
    }
}
```

The PURGE example above is fairly complete and deals with a non-standard method. Using `purge;` will remove all `Vary:-`variants of the object, unlike the older method of using `obj.ttl = 0s;` which had to be issued for each variants of an object.

Note

ACLs have not been explained yet, but will be explained in detail in later chapters.



7.4 The lookup that always misses

- `req.hash_always_miss = true;` in `vcl_recv` will cause Varnish to look the object up in cache, but ignore any copy it finds.
- Useful way to do a controlled refresh of a specific object, for instance if you use a script to refresh some slowly generated content.
- Depending on Varnish-version, it may leave extra copies in the cache
- If the server is down, the old content is left untouched

Using `return (pass);` in `vcl_recv`, you will always ask a backend for content, but this will never put it into the cache. Using `purge;` will remove old content, but what if the web server is down?

Using `req.has_always_miss = true;` tells Varnish to look the content up but, as the name indicates, always miss. This means that Varnish will first hit `vcl_miss` then (presumably) fetch the content from the web server, run `vcl_fetch` and (again, presumably) cache the updated copy of the content. If the backend server is down or unresponsive, the current copy of the content is untouched and any client that does not use `req.hash_always_miss=true;` will keep getting the old content as long as this goes on.

The two use-cases for this is controlling who takes the penalty for waiting around for the updated content, and ensuring that content isn't evicted until it's safe.

Warning

Varnish up until 3.0.2 does not do anything to evict old content after you have used `req.hash_always_miss` to update it. This means that you will have multiple copies of the content in cache. The newest copy will always be used, but if you cache your content for a long period of time, the memory usage will gradually increase.

This is a known bug, and hopefully fixed by the time you read this warning.



7.5 Banning

- Ban on anything
- Does not free up memory
- `ban req.url ~ "/foo"`
- `ban req.http.host ~ "example.com" && obj.http.content-type ~ "text"`
- `ban.list`
- In VCL: `ban("req.url ~ /foo");`

Banning in the context of Varnish refers to adding a ban to the ban-list. It can be done both through the command line interface, and through VCL, and the syntax is almost the same.

A ban is one or more statements in VCL-like syntax that will be tested against objects in the cache when they are looked up in the cache hash. A ban statement might be "the url starts with /sport" or "the object has a Server-header matching lighttpd".

Each object in the cache always points to an entry on the ban-list. This is the entry that they were last checked against. Whenever Varnish retrieves something from the cache, it checks if the objects pointer to the ban list is point to the top of the list. If it does not point to the top of the list, it will test the object against all new entries on the ban list and, if the object did not match any of them, update the pointer of the ban list.

There are pros and cons to this approach. The most obvious con is that no memory is freed: Objects are only tested once a client asks for them. A second con is that the ban list can get fairly large if there are objects in the cache that are rarely, if ever, accessed. To remedy this, Varnish tries to remove duplicate bans by marking them as "gone" (indicated by a G on the ban list). Gone bans are left on the list because an object is pointing to them, but are never again tested against, as there is a newer ban that supersedes it.

The biggest pro of the ban-list approach is that Varnish can add bans to the ban-list in constant time. Even if you have three million objects in your cache, adding a ban is instantaneous. The load is spread over time as the objects are requested, and they will never need to be tested if they expire first.

Tip

If the cache is completely empty, bans you add will not show up in the ban list. This can often happen when testing your VCL code during debugging.



7.6 VCL contexts when adding bans

- The context is that of the client present when testing, not the client that initiated the request that resulted in the fetch from the backend.
- In VCL, there is also the context of the client adding the item to the ban list. This is the context used when no quotation marks are present.

```
ban("req.url == " + req.http.x-url);
```

- `req.url` from the future client that will trigger the test against the object is used.
- `req.http.x-url` is the x-url header of the client that puts the ban on the ban list.

One of the typical examples of purging reads `ban("req.url == " + req.url)`, which looks fairly strange. The important thing to remember is that in VCL, you are essentially just creating one big string.

Tip

To avoid confusion in VCL, keep as much as possible within quotation marks, then verify that it works the way you planned by reviewing the ban list through the cli, using `ban.list`.



7.7 Smart bans

- When Varnish tests bans, any `req.*`-reference has to come from whatever client triggered the test.
- A "ban lurker" thread runs in the background to test bans on less accessed objects
- The ban lurker has no `req.*`-structure. It has no URL or Hostname.
- Smart bans are bans that only references `obj.*`
- Store the URL and Hostname on the object
- `set beresp.http.x-url = req.url;`
- `set beresp.http.x-host = req.http.host;`
- `ban obj.http.x-url ~ /something/.*`

Varnish now has a ban lurker thread, which will test old objects against bans periodically, without a client. For it to work, your bans can not refer to anything starting with `req`, as the ban lurker doesn't have any request data structure.

If you wish to ban on url, it can be a good idea to store the URL to the object, in `vcl_fetch`:

```
set beresp.http.x-url = req.url;
```

Then use that instead of `req.url` in your bans, in `vcl_recv`:

```
ban("obj.http.x-url == " + req.url);
```

This will allow Varnish to test the bans against less frequently accessed objects, so they do not linger in your cache just because no client asks for them just to discover they have been banned.



7.8 ban() or purge;?

- Banning is more flexible than `purge;`, but also slightly more complex
- Banning can be done from CLI and VCL, while `purge;` is only possible in VCL.
- Smart bans require that your VCL stores `req.url` (or any other fields you intend to ban on) ahead of time, even though banning on `req.url` directly will still work.
- Banning is not designed to free up memory, but smart bans using the ban lurker will still do this.

There is rarely a need to pick either bans or purges in Varnish, as you can have both. Some guidelines for selection, though:

- Any frequent automated or semi-automated cache invalidation will likely require VCL changes for the best effect, be it `purge;` or setting up smart bans.
- If you are invalidating more than one item at a time, you will either need a whole list, or need to use bans.
- If it takes a long time to pull content into Varnish, it's often a good idea to use `req.hash_always_miss` to control which client ends up waiting for the new copy. E.g: a script you control.



7.9 Exercise: Write a VCL for bans and purges

Write a VCL implementing a *PURGE* and *BAN* request method, which issues `purge;` and `ban();` respectively. The ban method should use the request headers `req.http.X-Ban-url` and `req.http.X-Ban-host` respectively. The VCL should use smart bans.

Do you get any artifacts from using smart bans, and can you avoid them?

To build further on this, you can also have a *REFRESH* method that fetches new content, using `req.hash_always_miss`.

To test this exercise you can use `lwp-request`. Example commands:

```
lwp-request -f -m PURGE http://localhost/testpage
lwp-request -f -m BAN -H 'X-Ban-Url: .*html$' -H 'X-Ban-Host: .*\.example\.com' http://localhost/
lwp-request -f -m REFRESH http://localhost/testpage
```

You may want to add `-USsed` to those commands to see the request and response headers.



7.10 Solution: Write a VCL for bans and purges

```
sub vcl_recv {
    if (req.request == "PURGE") {
        return (lookup);
    }
    if (req.request == "BAN") {
        ban("obj.http.x-url ~ " + req.http.x-ban-url +
            " && obj.http.x-host ~ " + req.http.x-ban-host);
        error 200 "Banned";
    }
    if (req.request == "REFRESH") {
        set req.request = "GET";
        set req.hash_always_miss = true;
    }
}

sub vcl_hit {
    if (req.request == "PURGE") {
        purge;
        error 200 "Purged";
    }
}

sub vcl_miss {
    if (req.request == "PURGE") {
        purge;
        error 404 "Not in cache";
    }
}

sub vcl_fetch {
    set beresp.http.x-url = req.url;
    set beresp.http.x-host = req.http.host;
}

sub vcl_deliver {
    unset resp.http.x-url;
    unset resp.http.x-host;
}
```



7.11 Exercise : PURGE an article from the backend

- Send a PURGE request to Varnish from your backend server after an article is published. The publication part will be simulated.
- The result should be that the article must be purged in Varnish.

Now you know that purging can be as easy as sending a specific HTTP request In order to help you have access to the file *article.php* which fakes an article. It is recommended to create a new page called *purgearticle.php*.



7.12 Solution : PURGE an article from the backend

article.php

```
<?php
header( "Cache-Control: public, must-revalidate, max-age=3600, s-maxage=3600" );

$date = new DateTime();
$now = $date->format( DateTime::RFC2822 );
?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head></head>
  <body>
    <h1>This is an article, cached for 1 hour</h1>

    <h2>Now is <?php echo $now; ?></h2>
    <a href="<?=$_SERVER['PHP_SELF']?>">Refresh this page</a>
  </body>
</html>
```



purgearticle.php

```
<?php
header( 'Content-Type: text/plain' );
header( 'Cache-Control: max-age=0' );
$hostname = 'localhost';
$port     = 80;
$URL      = '/article.php';
$debug    = true;

print "Updating the article in the database ...\n";
purgeURL( $hostname, $port, $URL, $debug );

function purgeURL( $hostname, $port, $purgeURL, $debug )
{
    $finalURL = sprintf(
        "http://%s:%d%s", $hostname, $port, $purgeURL
    );

    print( "Purging ${finalURL}\n" );

    $curlOptionList = array(
        CURLOPT_RETURNTRANSFER => true,
        CURLOPT_CUSTOMREQUEST  => 'PURGE',
        CURLOPT_HEADER          => true ,
        CURLOPT_NOBODY          => true,
        CURLOPT_URL              => $finalURL,
        CURLOPT_CONNECTTIMEOUT_MS => 2000
    );

    $fd = false;
    if( $debug == true ) {
        print "\n---- Curl debug ----\n";
        $fd = fopen("php://output", 'w+');
        $curlOptionList[CURLOPT_VERBOSE] = true;
        $curlOptionList[CURLOPT_STDERR]  = $fd;
    }

    $curlHandler = curl_init();
    curl_setopt_array( $curlHandler, $curlOptionList );
    curl_exec( $curlHandler );
    curl_close( $curlHandler );
    if( $fd != false ) {
        fclose( $fd );
    }
}
?>
```



default.vcl

```
backend default { .host = "localhost"; .port = "80"; }
acl purgers { "127.0.0.1"; }
sub vcl_recv {
    if (req.request == "PURGE") {
        if (!client.ip ~ purgers) {
            error 405 "Not allowed.";
        }
        return (lookup);
    }
}
sub vcl_hit {
    if (req.request == "PURGE") {
        purge;
        error 200 "Purged.";
    }
}
sub vcl_miss {
    if (req.request == "PURGE") {
        purge;
        error 200 "Purged.";
    }
}
```



8 Saving a request

This chapter is for the system administration course only

- Grace and grace mode
- Health checks
- Saint mode
- `return (restart);`
- Directors
- Using ACLs

Varnish has several mechanisms for recovering from problematic situations. It can retry a request to a different server, it can perform health checks, use an otherwise expired object and more.

This chapter discusses how these features interact with each other and how you can combine them to make your Varnish setup far more robust.



8.1 Core grace mechanisms

- A *graced* object is an object that has expired, but is still kept in cache
- *Grace mode* is when Varnish uses a *graced* object
- There is more than one way Varnish can end up using a *graced* object.
- `req.grace` defines how long overdue an object can be for Varnish to still consider it for *grace mode*.
- `beresp.grace` defines how long past the `beresp.ttl`-time Varnish will keep an object
- `req.grace` is often modified in `vcl_recv` based on the state of the backend.

When Varnish is in *grace mode*, it uses an object that has already expired as far as the TTL is concerned. There are several reasons this might happen, one of them being if a backend is marked as bad by a health probe.

For Varnish to be able to use a *graced* object, two things need to happen:

- The object needs to still be kept around. This is affected by `beresp.grace` in `vcl_fetch`.
- The VCL has to allow Varnish to use an object as overdue as the one kept around. This is affected by `req.grace` in `vcl_recv`.

When setting up *grace*, you will need to modify both `vcl_recv` and `vcl_fetch` to use *grace* effectively. The typical way to use *grace* is to store an object for several hours past its TTL, but only use it a few seconds after the TTL, except if the backend is sick. We will look more at health checks in a moment, but for now, the following VCL can illustrate a normal setup:

```
sub vcl_recv {
    if (req.backend.healthy) {
        set req.grace = 30s;
    } else {
        set req.grace = 24h;
    }
}

sub vcl_fetch {
    set beresp.grace = 24h;
}
```



8.2 req.grace and beresp.grace

```
set beresp.ttl=1m;  
set req.grace = 30s;  
set beresp.grace = 1h;
```

- 50s: Normal delivery
- 62s: Normal cache miss, but grace mode possible
- 80s: Normal cache miss, but grace mode possible
- 92s: Normal cache miss, grace mode possible but not allowed
- 3660s: (1h+1m) Object is removed from cache

In this time-line example, everything except the first normal delivery is assuming the object is never refreshed. If a cache miss happens at 62s and the object is refreshed, then 18 seconds later (80s) a request for the same resource would of course just hit the new 18 second old object.

The flip-side to this time line is if you set `req.grace` to 1h but leave `beresp.grace` to 30s instead. Even if grace is allowed for up to an hour, it's not possible since the object will be removed long before that.

The lesson to learn from this is simple: There is no point in setting `req.grace` to a value higher than `beresp.grace`, but there could be a point in setting `beresp.grace` higher than `req.grace`.

Tip

You can use `set req.grace = 0s;` to ensure that editorial staff doesn't get older objects (assuming they also don't hit the cache). The obvious downside of this is that you disable all grace functionality for these users, regardless of the reason.



8.3 When can grace happen

- A request is already pending for some specific content (deliver old content as long as fetching new content is in progress).
- No healthy backend is available
- You need health probes or saint mode for Varnish to consider the backend as unhealthy.

The original purpose of grace mode was to avoid piling up clients whenever a popular object expired from cache. So as long as a client is waiting for the new content, Varnish will prefer delivering graced objects over queuing up more clients to wait for this new content.

This is why setting `req.grace` to a low value is a good performance gain. It ensures that no client will get *too* old content, but as long as Varnish has a copy of the content and is in the progress of updating it, the old content will be sent. You can disable this entirely by setting `req.grace=0s`, and still use graced objects for unhealthy backends.



8.4 Exercise: Grace

1. Reuse the CGI script in `/usr/lib/cgi-bin/test.cgi`, but increase the sleep time and allow it to cache:

```
#!/bin/sh
sleep 15
echo "Content-type: text/plain"
echo "Cache-control: max-age=20"
echo
echo "Hello world"
date
```

2. Make it executable
3. Test that it works outside of Varnish
4. Set up `beresp.grace` and `req.grace` to 10s in VCL
5. Fire up a single request to warm the cache, it will take 15 seconds.
6. Fire up two requests roughly in parallel
7. Repeat until you can see how grace affects multiple clients

With this exercise, you should see that as long as the content is within the regular TTL, there is no difference. Once the TTL expires, the first client that asks for the content should be stuck for 15 seconds, while the second client should get the graced copy.

Also try setting `req.grace` to 0s and 10s while leaving `beresp.grace` intact, then do the opposite.

Bonus: What happens to the `Age`-header when it takes 15 seconds to generate a page?



8.5 Health checks

- Poke your web server every N seconds
- Affects backend selection
- `req.backend.healthy`
- Varnish needs at least *threshold* amount of good probes within a set of the last *window* probes. Where *threshold* and *window* are parameters.
- Set using `.probe`
- `varnishlog: Backend_health`
- `varnishadm: debug.health`

```
backend one {
    .host = "example.com";
    .probe = {
        .url = "/healthtest";
        .interval = 3s;
        .window = 5;
        .threshold = 2;
    }
}
```

You can define a health check for each backend, which will cause Varnish to probe a URL every few seconds. Normally, it will take more than one failed request before Varnish stops using a specific backend server.

The above example will cause Varnish to send a request to <http://example.com/healthtest> every 3 seconds. When deciding whether to use a server or not, it will look at the last 5 probes it has sent and require that at least 3 of them were good.

You also have an important variable called `.initial`, which defaults to the same value as `.threshold`. It defines how many probes Varnish should pretend are good when it first starts up. Before `.initial` was added, Varnish needed enough time to probe the Web server and gather good probes before it was able to start functioning after boot.

```
debug.health
200 545
Backend foo is Healthy
Current states good: 8 threshold: 5 window: 8
Average responsetime of good probes: 0.355237
Oldest                                                     Newest
=====
-----444444444444 Good IPv4
-----XXXXXXXXXX Good Xmit
-----RRRRRRRRRR Good Recv
-----HHHHHHHHHHHHHH Happy
```



The above shows the output of `debug.health` - the same data is also available in the more concise `Debug_health` tag of `varnishlog`.

Good IPv4 indicates that the IP was available for routing and that Varnish was able to connect over IPv4. *Good Xmit* indicates that Varnish was able to transmit data. *Good Recv* indicates that Varnish got a valid reply. *Happy* indicates that the reply was a 200 OK.

Note

Varnish does NOT send a Host header with health checks. If you need that, you can define the entire request using `.request` instead of `.url`.

```
backend one {
    .host = "example.com";
    .probe = {
        .request =
            "GET / HTTP/1.1"
            "Host: www.foo.bar"
            "Connection: close";
    }
}
```



8.6 Health checks and grace

- If a backend is marked as sick, grace mode is attempted
- You can use `req.backend.healthy` to alter `req.grace` when a backend is sick to allow Varnish to use even older content, if available.

When Varnish has no healthy backend available, it will attempt to use a graced copy of the object it is looking for. But all the rules you specify in VCL still apply.

Since you have `req.backend.healthy` available to you, you can use this to optionally increase `req.grace` just for requests to unhealthy backends.



8.7 Directors

- Contains 1 or more backends
- All backends must be known
- Multiple selection methods
- random, round-robin, hash, client and dns

```
backend one {
    .host = "localhost";
    .port = "80";
}

backend two {
    .host = "127.0.0.1";
    .port = "81";
}

director localhosts round-robin {
    { .backend = one; }
    { .backend = two; }
    { .backend = { .host = "localhost"; .port = "82"; } }
}

sub vcl_recv {
    set req.backend = localhosts;
}
```

Backend directors, usually just called directors, provide logical groupings of similar web servers. There are several different directors available, but they all share the same basic properties.

First of all, anywhere in VCL where you can refer to a backend, you can also refer to a director.

All directors also allow you to re-use previously defined backends, or define "anonymous" backends within the director definition. If a backend is defined explicitly and referred to both directly and from a director, Varnish will correctly record data such as number of connections (i.e.: max connections limiting) and saintmode thresholds. Defining an anonymous backend within a director will still give you all the normal properties of a backend.

And a director must have a name.

The simplest directors available are the round-robin director and the random director. The round-robin director takes no additional arguments - only the backends. It will pick the first backend for the first request, then the second backend for the second request, and so on, and start again from the top. If a health probe has marked a backend as sick, the round-robin director will skip it.

The random director picks a backend randomly. It has one per-backend parameter called *weight*, which provides a mechanism for balancing the traffic to the backends. It also provides a director-wide parameter called *retries* - it will try this many times to find a healthy backend.



The above example will result in twice as much traffic to localhost.

8.7.1 Client and hash directors

The client and hash directors are both special variants of the random director. Instead of a random number, the client director uses the `client.identity`. The `client.identity` variable defaults to the client IP, but can be changed in VCL. The same client will be directed to the same backend, assuming that the `client.identity` is the same for all requests.

Similarly, the hash director uses the hash data, which means that the same URL will go to the same web server every time. This is most relevant for multi-tiered caches.

For both the client and the hash director, the director will pick the next backend available if the preferred one is unhealthy.

8.7.2 The DNS director

The DNS director uses the Host header sent by a client to find a backend among a list of possibles. This allows dynamic scaling and changing of web server pools without modifying Varnish' configuration, but instead just waiting for Varnish to pick up on the DNS changes.

As the DNS director is perhaps the most complex, some extra explanation might be useful. Consider the following example VCL.

```
director mydirector dns {
    .list = {
        .port = "81";
        "192.168.0.0"/24;
    }
    .ttl = 5m;
    .suffix = "internal.example.net";
}

sub vcl_recv {
    set req.backend = mydirector;
}
```

It defines 255 backends, all in the 192.168.0.0/24 range. The DNS director can also use the traditional (non-list) format of defining backends, and most options are supported in `.list`, as long as they are specified before the relevant backends.

The TTL specified is for the DNS cache. In our example, the *mydirector* director will cache the DNS lookups for 5 minutes. When a client asks for `www.example.org`, Varnish will look up `www.example.org.internal.example.net`, and if it resolves to something, the DNS director will check if one of the backends in the 192.168.0.0/24 range matches, then use that.



8.8 Demo: Health probes and grace



8.9 Saint mode

- Saint mode marks an object as sick for a specific backend for a period of time
- The rest of Varnish just sees a sick backend, be it for grace or backend selection
- Other content from the same backend can still be accessed
- ... unless more than a set amount of objects are added to the saintmode black list for a specific backend, then the entire backend is considered sick.
- Normal to restart after setting `beresp.saintmode = 20s;` in `vcl_fetch`

Saint mode is meant to complement your regular health checks. Some times you just can't spot a problem in a simple health probe, but it might be obvious in `vcl_fetch`.

An example could be a thumbnail generator. When it fails it might return "200 OK", but no data. You can spot that the *Length*-header is 0 in `vcl_fetch`, but the health probes might not be able to pick up on this.

In this situation you can set `beresp.saintmode = 20s;`, and Varnish will not attempt to access that object (aka: URL) from that specific backend for the next 20 seconds. If you restart and attempt the same request again, Varnish will either pick a different backend if one is available, or try to use a graced object, or finally deliver an error message.

If you have more than 10 [objects] (default) objects black listed for a specific backend, the entire backend is considered sick. The rationale is that if 10 URLs already failed, there's probably no reason to try an 11th.

There is no need to worry about recovering. The object will only be on the saint list for as long as you specify, regardless of whether the threshold is reached or not.

Use saint mode to complement your health checks. They are meant to either help Varnish "fail fast" for a backend that has failed, until the health probes can take over, or catch errors that are not possible to spot with the health checks.

As such, it's advised to keep the saint period short. Typical suggestions are 20 seconds, 30 seconds, etc.



8.10 Restart in VCL

- Start the VCL processing again from the top of `vcl_recv`.
- Any changes made are kept.
- Parameter `max_restarts` safe guards against infinite loops
- `req.restarts` counts the number of restarts

```
sub vcl_fetch {
    if (req.restarts == 0 &&
        req.request == "GET" &&
        beresp.status == 301) {
        set beresp.http.location = regsub(beresp.http.location, "^http://", "");
        set req.http.host = regsub(beresp.http.location, ".*$", "");
        set req.url = regsub(beresp.http.location, "[^/]*", "");
        return (restart);
    }
}
```

Restarts in VCL can be used everywhere.

They allow you to re-run the VCL state engine with different variables. The above example simply executes a redirect without going through the client. An other example is using it in combination with PURGE and rewriting so the script that issues PURGE will also refresh the content.

Yet another example is to combine it with saint mode.

Note

Varnish version 2.1.5 is the first version where `return(restart);` is valid in `vcl_deliver`, making it available everywhere.



8.11 Backend properties

- Most properties are optional

```
backend default {
    .host = "localhost";
    .port = "80";
    .connect_timeout = 0.5s;
    .between_bytes_timeout = 5s;
    .saintmode_threshold = 20;
    .first_byte_timeout = 20s;
    .max_connections = 50;
}
```

All the backend-specific timers that are available as parameters can also be overridden in the VCL on a backend-specific level.

While the timeouts have already been discussed, there are some other notable parameters.

The saintmode threshold defines how many items can be blacklisted by saint mode before the entire backend is considered sick. Saint mode will be discussed in more detail.

If your backend is struggling, it might be advantageous to set `max_connections` so only a set number of simultaneous connections will be issued to a specific backend.

Tip

Varnish only accepts hostnames for backend servers that resolve to a maximum of one IPv4 address *and* one IPv6 address. The parameter `prefer_ipv6` defines which one Varnish will prefer.



8.12 Example: Evil backend hack

You can not use `saintmode` in `vcl_error` and health probes can be slow to pick up on trouble. So, in order to act on a failing backend right away you can use the supplied hack to force delivery of graced object right away.

You can use a fake backend that's always sick to force a grace copy. This is considered a rather dirty hack that works.

```
backend normal {
    .host = "localhost";
    .probe = { .url = "/"; }
}

backend fail {
    .host = "localhost";
    .port = "21121";
    .probe = { .url = "/asfasfasf"; .initial = 0; .interval = 1d; }
}

sub vcl_recv {
    if (req.restarts == 0) {
        set req.backend = normal;
    } else {
        set req.backend = fail;
    }

    if (req.backend.healthy) {
        set req.grace = 30s;
    } else {
        set req.grace = 24h;
    }
}

sub vcl_fetch {
    set beresp.grace = 24h;
}

sub vcl_error {
    if (req.restarts == 0) {
        return (restart);
    }
}
```



8.13 Access Control Lists

- An ACL is a list of IPs or IP ranges.
- Compare with `client.ip` or `server.ip`

```
acl management {
    "172.16.0.0"/16;
}

acl sysadmins {
    "192.168.0.0"/16;
    ! "192.168.0.1";
}

sub vcl_recv {
    if (client.ip ~ management) {
        set req.url = regsub(req.url, "^", "/proper-stuff");
    } elseif (client.ip ~ sysadmins) {
        set req.url = regsub(req.url, "^", "/cool-stuff");
    }
}
```

ACLs are fairly simple. A single IP is listed as "192.168.1.2", and to turn it into an IP-range, add the /24 *outside* of the quotation marks ("192.168.1.0"/24). To exclude an IP or range from an ACL, precede it with an exclamation mark - that way you can include all the IPs in a range except the gateway, for example.

ACLs can be used for anything. Some people have even used ACLs to differentiate how their Varnish servers behaves (e.g.: A single VCL for different Varnish servers - but it evaluates `server.ip` to see where it really is).

Typical use cases are for PURGE requests, bans or avoiding the cache entirely.



8.14 Exercise: Combine PURGE and restart

- Re-write the PURGE example to also issue a restart
- The result should be that a PURGE both removes the content and fetches a new copy from the backend.





8.15 Solution: Combine PURGE and restart

```
acl purgers {
    "127.0.0.1";
    "192.168.0.0"/24;
}

sub vcl_recv {
    if (req.restarts == 0) {
        unset req.http.X-purger;
    }
    if (req.request == "PURGE") {
        if (!client.ip ~ purgers) {
            error 405 "Method not allowed";
        }
        return (lookup);
    }
}

sub vcl_hit {
    if (req.request == "PURGE") {
        purge;
        set req.request = "GET";
        set req.http.X-purger = "Purged";
        error 800 "restart";
    }
}

sub vcl_miss {
    if (req.request == "PURGE") {
        purge;
        set req.request = "GET";
        set req.http.X-purger = "Purged-possibly";
        error 800 "restart";    # cant restart in miss, yet. go via error
    }
}

sub vcl_error {
    if (obj.status == 800 ) {
        return(restart);
    }
}

sub vcl_pass {
    if (req.request == "PURGE") {
        error 502 "PURGE on a passed object";
    }
}
```



```
sub vcl_deliver {
    if (req.http.X-purger) {
        set resp.http.X-purger = req.http.X-purger;
    }
}
```

Note

Whenever you are using `req.http` to store an internal variable, you should get used to unsetting it in `vcl_recv` on the first run. Otherwise a client could supply it directly. In this situation, the outcome wouldn't be harmful, but it's a good habit to establish.



9 Content Composition

This chapter is for the webdeveloper course only

You now know almost all you need to know to adapt your site to work well with Varnish. In this chapter, we will look closer at how to glue your content together. We will look at:

- AJAX and masquerading AJAX requests through Varnish.
- Cookies and how you can work with them.
- Edge Side Includes (ESI) and how you can compose a single client-visible page out of multiple objects.
- Combining ESI and Cookies.

While you may or may not be comfortable in PHP, it should be easy to re-use the same ideas in other languages after you've finished this chapter.



9.1 A typical site

Most websites follow a pattern, with easily distinguishable parts:

- A front page.
- Articles or sub-pages.
- A login-box or "home bar".
- Static elements, like CSS, JavaScript and graphics.

To truly utilize Varnish to its full potential, you have to start by mentally organizing your own site. Ask yourself this:

- What makes this page unique, and how can I let caches know.

Beginning with the static elements should be easy. You already know what you need to know to handle those.

An other easy option is to only cache content for users that are not logged in. For news-papers, that's probably enough. For a web-shop, that's not going to cut it.

But even for a web-shop, you can frequently re-use objects. If you can isolate the user-specific bits, like the shopping cart, you can cache the rest. You could even cache the shopping cart, if you told Varnish when it changed.

The most important lessons, though, is to start with what you know.



9.2 Cookies

Cookies are frequently used to identify unique users, or user-choices. They can be used for anything from identifying a user-session in a web-shop to opting out of a sites mobile-version. There are three ways cookies can be handled:

- The client can (and will) send a Cookie request-header containing all cookies that matches that site and path.
- The server can set a cookie by returning a Set-Cookie response-header.
- You can modify cookies through JavaScript.

We will not look too closely at the JavaScript-method, but it is often necessary to go down that road for user-specific content. We'll see why soon enough.

For Varnish, there are several ways to handle Cookies.



9.3 Vary and Cookies

- The Vary-header can be used to let caches cache content that is based on the value of cookies.
- Cookies are widely used
- ... but almost no-one sends `Vary: Cookie` for content that does, indeed, vary based on the Cookie.
- Thus: Varnish does not cache when cookies are involved, by default.

There is a good chance that you never knew what the Vary-header did before you begun this course. You are not alone. However, many people know how to store and retrieve cookies.

If Varnish' default VCL only obeyed the HTTP standard, you would be able to cache content freely, regardless of the cookies a client sent. If the server generated different pages based on the cookie-header, it would signal that by sending a Vary response-header with Cookie in it. Sadly, that's not the case.

To avoid cache collisions and littering the cache with large amount of copies of the same content, Varnish does not cache a page if the Cookie request-header or Set-Cookie response header is present.

You can force it, by issuing `return (lookup);` in `vcl_recv`, and similar actions for Set-Cookie, and you'll most likely have to. But be careful, or you end up giving a page generated based on a cookie to the wrong person.



9.4 Best practices for cookies

- Remove all cookies you know you do not need, then cache if none are left.
- Use URL schemes that let you easily determine if a page needs a cookie or not. E.g:
 - /common/ - strip all cookies.
 - /user/ - Leave user-cookies.
 - /voucher/ - Only leave the voucher-cookie.
 - etc.
- Once you have a URL scheme that works, add the req.http.cookie to the cache hash in *vcl_hash*:
`hash_data(req.http.cookie);`
- Never cache a *Set-Cookie* header. Either remove the header before caching or don't cache the object at all.
- Avoid using `return (deliver);` more than once in *vcl_fetch*. Instead, finish up with something similar to:

```
if (beresp.ttl > 0s) {  
    unset beresp.http.set-cookie;  
}
```

This will ensure that all cached pages are stripped of set-cookie.

A golden rule through all of this is: It's far better to either NOT cache or cache multiple copies of the same content for each user than it is to deliver the wrong content to the wrong person.

Your worst-case scenario should be a broken cache and overloaded web servers, not a compromised user-account and a lawsuit.



9.5 Exercise: Compare Vary and hash_data

Both a `Vary: Cookie` response-header and `hash_data(req.http.cookie);` will create separate objects in the cache. This exercise is all about Vary- and hash-dynamics.

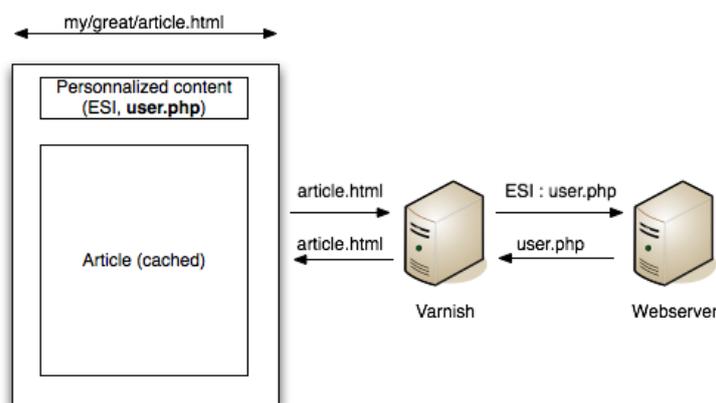
1. Use the `purge;` code from previous chapters.
2. Test with `curl --cookie "user=John" http://localhost/cookies.php`
3. Force Varnish to cache, despite the client sending a Cookie header
4. Change the cookie, and see if you get a new value.
5. Make `cookies.php` send a `Vary: Cookie` header, then try changing the cookie again.
6. Try to PURGE. Check if it affects all, none or just one of the objects in cache (e.g: change the cookie-value and see if PURGE has purged all of them).
7. Remove `beresp.http.Vary` in `vcl_fetch` and see if Varnish will still honor the Vary-header.
8. Add `hash_data(req.http.cookie);` in `vcl_hash`. Check how multiple cookie-values will give individually-cached pages.
9. Try PURGE now that you use `hash_data()` instead of Vary.

Once you've done this exercise, you should have a very good idea on how both Vary and `hash_data();` works. We only looked at it for the Cookie header, but the same rules would apply to any other header too.



9.6 Edge Side Includes

- What is ESI
- How to use ESI
- Testing ESI without Varnish



Edge Side Includes or ESI is a small markup language for dynamic web content assembly at the reverse proxy level. The reverse proxy analyses the HTML code, parses ESI specific markup and assembles the final result before flushing it to the client.

With ESI, Varnish can be used not only to deliver objects, but to glue them together. The most typical use case for ESI is a news article with a "most recent news" box at the side. The article itself is most likely written once and possibly never changed, and can be cached for a long time. The box at the side with "most recent news", however, will change frequently. With ESI, the article can include a "most recent news" box with a different TTL.

Varnish would then first fetch the news article from a web server, then parse it for ESI content, see the `<esi:include src="/top.html">` item, then fetch `/top.html` as if it was a normal object, either finding it already cached or getting it from a web server and inserting it into cache. The TTL of `/top.html` can be 5 minutes while the article is cached for two days. Varnish will know that it has to glue the page together from two different objects when it sends it, and thus it will update the parts independently and always use the most updated version.



9.7 Basic ESI usage

Enabling ESI in Varnish is simple enough:

```
sub vcl_fetch {
    set beresp.do_esi = true;
}
```

To include a page in another, the `<esi:include>` tag is used:

```
<esi:include src="/url" />
```

You can also strip cookies for the top-element of an ESI page, but leave them for the sub-page. This is done in `vcl_recv`.

Varnish only supports the three following tags:

- `<esi:include>` : calls the page defined in the "src" attribute and inserts it in the page where the tag has been placed.
- `<esi:remove>` : removes any code inside this opening and closing tag.
- `<!--esi `(content) -->`: Leaves (content) unparsed. E.g, the following will not perform substitution for the `<esi:include... tag`:

```
<!--esi
    An esi tag looks like: <esi:include src="example">
-->
```

Note

By default, Varnish refuses to parse content for ESI if it does not *look* like XML. That means that it has to start with a `<`-sign. You should be able to see ESI parse errors both in `varnishstat` and `varnishlog`, though you may have to look closely.



9.8 Exercise: Enable ESI and Cookies

Use the *esi-top.php* and *esi-user.php*-files to test ESI.

1. Visit the *esi-top.php*-page and observe that the ESI-markup is clearly visible.
2. Enable ESI in Varnish and re-test.
3. Strip all cookies from *esi-top.php* and make it cache.
4. Let the user-page cache too. It emits `Vary: Cookie`, but might need some help.

Try using `return(lookup)` in *vcl_recv* as little as you can, and `return(deliver);` in *vcl_fetch* as little as you can. This is a general rule, that will train you to make safer Varnish setups.

During the exercise, make sure you understand all the cache mechanisms at play. You can also try removing the `Vary: Cookie`-header from *esi-user.php* and test.

You may also want to try `PURGE`. You will have to purge each of the objects: Purging just */esi-top.php* will not automatically purge */esi-user.php*.



9.9 Testing ESI without Varnish

- You can test ESI Using JavaScript to fill in the blanks

During the development period you might not need Varnish all the time as it might make you less comfortable when adding a particular feature. There is a solution based on JavaScript that you could use to interpret ESI syntax without having to use Varnish at all. You can download the library at the following URL:

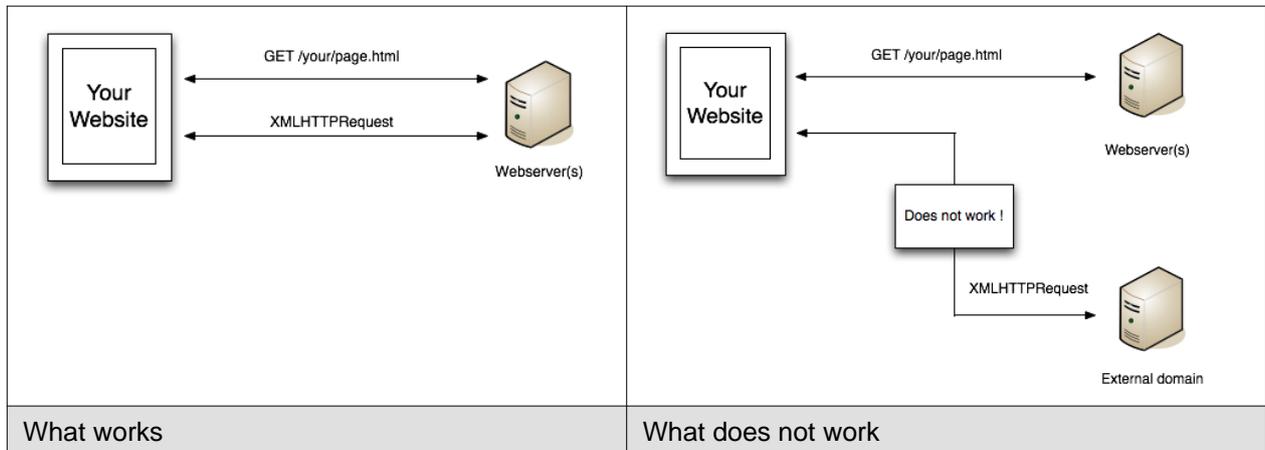
- http://www.catalystframework.org/calendar/static/2008/esi/ESI_Parser.tar.gz

Once downloaded, extract it in your code base, include *esiparser.js* and include the following JavaScript code to trigger the ESI parser:

```
$(document).ready( function () { do_esi_parsing(document); });
```



9.10 Masquerading AJAX requests



With AJAX it is not possible to send requests to a request across another domain. This is a security restriction imposed by browsers. This issue can be easily solved by using Varnish and VCL.



9.11 Exercise : write a VCL that masquerades XHR calls

By using the *ajax.html* page provided write a VCL that masquerades Ajax requests.



9.12 Solution : write a VCL that masquerades XHR calls

ajax.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head>
    <script type="text/javascript" src="http://ajax.googleapis.com/ajax/libs/jquery/1.4/jquery.min.js">
    </script>
    <script type="text/javascript">
      function getNonMasqueraded()
      {
        $("#result").load( "http://www.google.com/robots.txt" );
      }

      function getMasqueraded()
      {
        $("#result").load( "/masq/robots.txt" );
      }
    </script>
  </head>
  <body>
    <h1>Cross-domain Ajax</h1>
    <ul>
      <li><a href="javascript:getNonMasqueraded()">Test a non masqueraded cross-domain request</a></li>
      <li><a href="javascript:getMasqueraded()">Test a masqueraded cross-domain request</a></li>
    </ul>

    <h1>Result</h1>
    <div id="result"></div>
  </body>
</html>
```



default.vcl

```
backend google {
    .host = "209.85.147.106";
    .port = "80";
}

sub vcl_fetch {
    if (req.url ~ "^/masq") {
        set req.backend = google;
        set req.http.host = "www.google.com";
        set req.url = regsub(req.url, "^/masq", "");
        remove req.http.Cookie;
        return(deliver);
    }
    /* [...] */
}
```



10 Finishing words



10.1 Varnish 2.1 to 3.0

Varnish 3.0, in addition to new features, also changed several aspects of VCL and parameters.

Varnish 2.1	Varnish 3.0
<code>vcl_fetch: return (pass);</code>	<code>vcl_fetch: return (hit_for_pass);</code>
<code>vcl_recv: return (pass);</code>	<code>vcl_recv: return (pass);</code>
<code>purge(...);</code>	<code>ban(...);</code>
<code>C{ VRT_Nuke(...); }C</code>	<code>purge;</code>
<code>set req.url = "/test" req.url;</code>	<code>set req.url = "/test" + req.url;</code>
<code>log "something";</code>	<code>import std; std.log("something");</code>
<code>"%2520" is literal %20</code>	<code>"%20" - no more %-escapes</code>
<code>set req.hash += req.url</code>	<code>hash_data(req.url);</code>
<code>esi;</code>	<code>set beresp.do_es = true;</code>
<i>thread_pool_max</i> does not depend on <i>thread_pools</i> , but <i>thread_pool_min</i> does.	Both <i>thread_pool_max</i> and <i>thread_pool_min</i> are per thread pool
<code>thread_pool_max=200</code> and <code>thread_pools=8</code> means max 200 total threads.	<code>thread_pool_max=200</code> and <code>thread_pools=8</code> means max 1600 total threads



10.2 Resources

- RFC 2616

Community driven:

- <http://varnish-cache.org>
- <http://varnish-cache.org/docs/>
- <http://repo.varnish-cache.org/>
- <http://varnish-cache.org/wiki/VCLExamples>
- Public mailing lists: <http://varnish-cache.org/wiki/MailingLists>
- Public IRC channel: #varnish at irc.linpro.no

Commercial:

- <http://planet.varnish-cache.org/>
- <http://www.varnish-software.com>
- <http://repo.varnish-software.com> (for service agreement customers)
- support@varnish-software.com (for existing customers, with SLA)
- sales@varnish-software.com



11 Appendix A: Varnish Programs

SHMLOG tools

- varnishlog
- varnishncsa
- varnishstat
- varnishhist
- varnishtop
- varnishsizes

Administration

- varnishadm

Misc

- varnishtest
- varnishreplay

Varnish provides several tools to help monitor and control Varnish. `varnishadm`, used to access the management interface, is the only one that can affect a running instance of Varnish.

All the other tools operate exclusively on the shared memory log, often called `shmlog` in the context of Varnish. They take similar (but not identical) command line arguments, and use the same underlying API.

Among the log-parsing tools, `varnishstat` is so far unique in that it only looks at counters. The counters are easily found in the `shmlog`, and are typically polled at reasonable interval to give the impression of real-time updates. Counters, unlike the rest of the log, are not directly mapped to a single request, but represent how many times some specific action has occurred since Varnish started.

The rest of the tools work on the round robin part of the `shmlog`, which deals with specific requests. Since the `shmlog` provides large amounts of information, it is usually necessary to filter it. But that does not just mean "show me everything that matches X". The most basic log tool, `varnishlog`, will do precisely that. The rest of the tools, however, can process the information further and display running statistical information.

If `varnishlog` is used to dump data to disk, `varnishreplay` can simulate a similar load. `varnishtest` is used for regression tests, mainly during development. Both are outside the scope of this course.

Note

There is a delay in the log process, though usually it is not noticeable. The `shmlog` is 80MB large by default, which gives some potential history, but that is not guaranteed and it depends heavily on when the last roll-around of the `shmlog` occurred.



11.1 varnishtop

```
varnishtop -i TxStatus

list length 6                                     hostname

3864.45 TxStatus      200
1001.33 TxStatus      304
 33.93 TxStatus      301
  3.99 TxStatus      302
  3.00 TxStatus      404
  1.00 TxStatus      403
```

- Group tags and tag-content by frequency

varnishtop groups tags and the content of the tag together to generate a sorted list of the most frequently appearing tag/tag-content pair.

Because the usefulness is only visible once you start filtering, it is often overlooked. The above example lists status codes that Varnish returns.

Two of the perhaps most useful variants of varnishtop is:

- `varnishtop -i TxUrl` creates a list of URLs requested from a web server. Use this to find out what is causing back-end traffic and start hitting items on the top of the list.
- `varnishtop -i TxStatus` lists what status codes Varnish returns to clients. (As shown above)

Some other possibly useful examples are:

- `varnishtop -i RxUrl` displays what URLs are most frequently requested from a client.
- `varnishtop -i RxHeader -I 'User-Agent:.*Linux.*'` lists User-Agent headers with "Linux" in it (e.g: most used Linux web browsers, that report them self as Linux).
- `varnishtop -i RxStatus` will list status codes received from a web server.
- `varnishtop -i VCL_call` shows what VCL functions are used.
- `varnishtop -i RxHeader -I Referrer` shows the most common referrer addresses.



11.2 varnishncsa

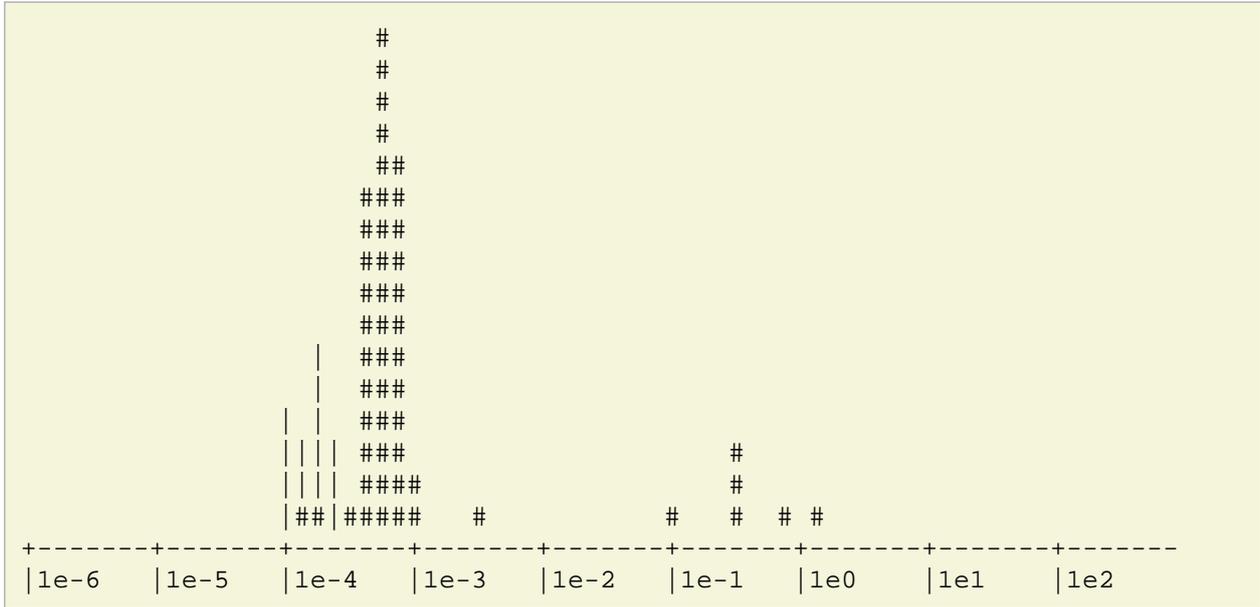
```
10.10.0.1 - - [24/Aug/2008:03:46:48 +0100] "GET \  
http://www.example.com/images/foo.png HTTP/1.1" 200 5330 \  
"http://www.example.com/" "Mozilla/5.0"
```

If you already have tools in place to analyze Apache-like logs (NCSA logs), varnishncsa can be used to print the shmlog as ncsa-styled log.

Filtering works similar to varnishlog.



11.3 varnishhist



11.4 Exercise: Try the tools

- Send a few requests to Varnish using `GET -e http://localhost:8000`
- verify you have some cached objects using `varnishstat`
- look at the communication with the clients, using `varnishlog`. Try sending various headers and see them appear in `varnishlog`.
- Install `siege`
- Run `siege` against `localhost` while looking at `varnishhist`



12 Appendix B: Extra Material

The following is content needed for some of the exercises.



12.1 ajax.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head>
    <script type="text/javascript" src="http://ajax.googleapis.com/ajax/libs/jquery/1.4/jquery.min.js">
    </script>
    <script type="text/javascript">
      function getNonMasqueraded()
      {
        $("#result").load( "http://www.google.com/robots.txt" );
      }

      function getMasqueraded()
      {
        $("#result").load( "/masq/robots.txt" );
      }
    </script>
  </head>
  <body>
    <h1>Cross-domain Ajax</h1>
    <ul>
      <li><a href="javascript:getNonMasqueraded()">Test a non masqueraded cross-domain request</a></li>
      <li><a href="javascript:getMasqueraded()">Test a masqueraded cross-domain request</a></li>
    </ul>

    <h1>Result</h1>
    <div id="result"></div>
  </body>
</html>
```



12.2 article.php

```
<?php
header( "Cache-Control: public, must-revalidate, max-age=3600, s-maxage=3600" );

$date = new DateTime();
$now = $date->format( DateTime::RFC2822 );
?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head></head>
  <body>
    <h1>This is an article, cached for 1 hour</h1>

    <h2>Now is <?php echo $now; ?></h2>
    <a href="<?=$_SERVER['PHP_SELF']?>">Refresh this page</a>
  </body>
</html>
```



12.3 cookies.php

```
<?php
header( 'Content-Type: text/plain' );

print( "The following cookies have been received by the server\n" );

foreach( $_COOKIE as $name => $value )
    print( "- ${name} : ${value}\n" );
?>
```



12.4 esi-top.php

```
<?php
header('Content-Type: text/html');
header('Cache-Control: max-age=30, s-maxage=3600');
$date = new DateTime();
$now = $date->format( DateTime::RFC2822 );
$setc = "";
if( isset($_POST['k']) and $_POST['k'] != '' and
    isset($_POST['v']) and $_POST['v'] != '' ) {
    $k=$_POST['k'];
    $v=$_POST['v'];
    $setc = "Set-Cookie: $k=$v";

    header($setc);
    ?><meta http-equiv="refresh" content="1" />
    <h1>Refreshing to set cookie <?php print $setc; ?></h1><?php
}
?>
<html><head><title>ESI top page</title></head><body><h1>ESI Test page</h1>
<p>This is content on the top-page of the ESI page. The top page is cached for 1 hour in Varnish, but only 30 seconds on the client.</p> <p>The time when the top-element was created:</p><h3>
<?php echo $now; ?>

<h1>Set a cookie:</h1><form action="/esi-top.php" method="POST">
Key: <input type="text" name="k">
Value: <input type="text" name="v">
<input type="submit"> </form>

</h3><p>The top page received the following Cookies:</p><ul>
<?php
foreach( $_COOKIE as $name => $value )
    print( "<li>{$name} : {$value}</li>\n" );
?>

<table border="1"><tr><td>esi:include src="/esi-user.php" /></td></tr></table></body></html>
```



12.5 esi-user.php

```
<?php
header('Content-Type: text/html');
header('Cache-Control: max-age=30, s-maxage=20');
header('Vary: Cookie');
$date = new DateTime();
$now = $date->format('DateTime:YMDH22');
?>
<p>This is content on the user-specific ESI-include. This part of the page is can be cached in Varnish separately since it emits a 'Vary: Cookie'-header. We can not affect the client-cache of this sub-page, since that is determined by the cache-control headers on the top-element.</p>
<p>The time when the user-specific-element was created:</p><h3>
<?php echo "Now: ?>

</h3><p>The user-specific page received the following Cookies:</p><ul>
<?php
foreach( $_COOKIE as $name => $value )
    print "<li>[name] : [value]</li></ul>";
?>
</ul>
```





12.6 httpheadersexample.php

```

<?php
define( 'LAST_MODIFIED_STRING', 'Sat, 09 Sep 2000 22:00:00 GMT' );

// expires_date : 10s after page generation
$expires_date = new DateTime();
$expires_date->add(new DateInterval('PT10S'));

$headers = array(
    'Date' => date( 'D, d M Y H:i:s', time() ),
);

if( isset( $_GET['h'] ) and $_GET['h'] !== '' )
{
    switch( $_GET['h'] )
    {
        case "expires" :
            $headers['Expires'] = toUTCDate($expires_date);
            break;

        case "cache-control":
            $headers['Cache-Control'] = "public, must-revalidate, max-age=3600, s-maxage=3600";
            break;

        case "cache-control-override":
            $headers['Expires'] = toUTCDate($expires_date);
            $headers['Cache-Control'] = "public, must-revalidate, max-age=2, s-maxage=2";
            break;

        case "last-modified":
            $headers['Last-Modified'] = LAST_MODIFIED_STRING;
            $headers['Etag'] = md5( 12345 );

            if( isset( $_SERVER['HTTP_IF_MODIFIED_SINCE'] ) and
                $_SERVER['HTTP_IF_MODIFIED_SINCE'] == LAST_MODIFIED_STRING ) {
                header( "HTTP/1.1 304 Not Modified" );
                exit( );
            }
            break;

        case "vary":
            $headers['Expires'] = toUTCDate($expires_date);
            $headers['Vary'] = 'User-Agent';
            break;
    }

    sendHeaders( $headers );
}

```

```

}

function sendHeaders( array $headerList )
{
    foreach( $headerList as $name => $value )
    {
        header( "{$name}: {$value}" );
    }
}

```



```
    }
}

function toUTCDate( DateTime $date )
{
    $date->setTimezone( new DateTimeZone( 'UTC' ) );
    return $date->format( 'D, d M Y H:i:s \G\M\T' );
}
?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head></head>
  <body>
    <h1>Headers sent</h1>
    <?php
      foreach( $headers as $name => $value ) {
        print "<strong>{$name}</strong>: {$value}<br/>";
      }

      if( isset( $_SERVER['HTTP_IF_MODIFIED_SINCE'] ) ) {
        print "<strong>If-Modified-Since</strong> has been sent in the";
        print "request, value : " . $_SERVER['HTTP_IF_MODIFIED_SINCE'];
      }
    ?>
    <hr/>
    <h1>Links for testing</h1>
    <ul>
      <li><a href="<?=$_SERVER['PHP_SELF']?>?h=expires">Test Expires response header</a></li>
      <li><a href="<?=$_SERVER['PHP_SELF']?>?h=cache-control">Test Cache-Control response header</a></li>
      <li><a href="<?=$_SERVER['PHP_SELF']?>?h=cache-control-override">Test Cache-Control response header overrides Expires</a></li>
      <li><a href="<?=$_SERVER['PHP_SELF']?>?h=last-modified">Test Last-Modified/If-modified-since response header</a></li>
      <li><a href="<?=$_SERVER['PHP_SELF']?>?h=vary">Test Vary response header</a></li>
    </ul>
  </body>
</html>
```



12.7 purgearicle.php

```
<?php
header( 'Content-Type: text/plain' );
header( 'Cache-Control: max-age=0' );
$hostname = 'localhost';
$port     = 80;
$URL      = '/article.php';
$debug    = true;

print "Updating the article in the database ...\n";
purgeURL( $hostname, $port, $URL, $debug );

function purgeURL( $hostname, $port, $purgeURL, $debug )
{
    $finalURL = sprintf(
        "http://%s:%d%s", $hostname, $port, $purgeURL
    );

    print( "Purging ${finalURL}\n" );

    $curlOptionList = array(
        CURLOPT_RETURNTRANSFER => true,
        CURLOPT_CUSTOMREQUEST  => 'PURGE',
        CURLOPT_HEADER         => true ,
        CURLOPT_NOBODY          => true,
        CURLOPT_URL             => $finalURL,
        CURLOPT_CONNECTTIMEOUT_MS => 2000
    );

    $fd = false;
    if( $debug == true ) {
        print "\n---- Curl debug ----- \n";
        $fd = fopen("php://output", 'w+');
        $curlOptionList[CURLOPT_VERBOSE] = true;
        $curlOptionList[CURLOPT_STDERR] = $fd;
    }

    $curlHandler = curl_init();
    curl_setopt_array( $curlHandler, $curlOptionList );
    curl_exec( $curlHandler );
    curl_close( $curlHandler );
    if( $fd != false ) {
        fclose( $fd );
    }
}
?>
```



12.8 test.php

```
<?php
$cc = "";
if( isset($_GET['k']) and $_GET['k'] != '' and
    isset($_GET['v']) and $_GET['v'] != '' ) {
    $k=$_GET['k'];
    $v=$_GET['v'];
    $cc = "Cache-Control: $k=$v";

    header("$cc");
}
?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head></head>
  <body>
    <h1>Cache-Control Header:</h1>
    <?php
      print "<pre>$cc</pre>\n";
    ?>
    <hr/>
    <h1>Links for testing</h1>
    <form action="/test.php" method="GET">
      Key: <input type="text" name="k">
      Value: <input type="text" name="v">
      <input type="submit">
    </form>
  </body>
</html>
```



12.9 set-cookie.php

```
<?php
header("Cache-Control: max-age=0");
$cc = "";
if( isset($_POST['k']) and $_POST['k'] != '' and
    isset($_POST['v']) and $_POST['v'] != '' ) {
    $k=$_POST['k'];
    $v=$_POST['v'];
    $setc = "Set-Cookie: $k=$v";

    header("$setc");

}
?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head></head>
  <body>
    <h1>Set-Cookie Header:</h1>
    <?php
      print "<pre>$setc</pre>\n";
    ?>
    <hr/>
    <h1>Links for testing</h1>
    <form action="/set-cookie.php" method="POST">
      Key: <input type="text" name="k">
      Value: <input type="text" name="v">
      <input type="submit">
    </form>
  </body>
</html>
```

