Sweeten Your Yocto Build Times with Icecream

Joshua Watt
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Joshua Watt
About Me

- Worked for Garmin for the past 10 years
- Worked with Yocto for the past 4 years
  - I’ve been using icecream for most of that time
- Joshua.Watt@garmin.com
- JPEWhacker@gmail.com
Outline

- What is Icecream?
- Why use Icecream?
- How to use Icecream
- Maximizing Performance
- What’s next
- Conclusion
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What is Icecream?

- [https://github.com/icecc/icecream](https://github.com/icecc/icecream)
- A distributed compiler, similar to distcc
  - Unlike distcc, it uses single scheduler to dispatch jobs between the various nodes
- Open Source
Advantages of a central scheduler

- Quickly make node selections
- Better distribution of jobs across the cluster
- Holistic approach to scheduling tasks
- Easier cluster administration
What is Icecream?

Node A icecc (shim)

Node A iceccd (daemon)

Scheduler

Node B iceccd (daemon)

Node A gcc

Node A Toolchain
Outline

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Performance Testing

- `$ bitbake --runonly unpack core-image-minimal && bitbake core-image-minimal`
- Results analyzed using buildstats tools
  - 15 test builds
- [https://github.com/JPEWdev/oe-icecream-demo](https://github.com/JPEWdev/oe-icecream-demo)
Testing Environment

- Garmin’s icecream cluster:
  - ~21 compile nodes
  - ~184 total job capacity

- Test machine:
  - Quad core i7 CPU @ 3.4 GHz
  - 16 GB Memory
  - 1 TB spindle HD
  - Fedora 30
## Results (CPU time)

<table>
<thead>
<tr>
<th>PKG</th>
<th>TASK</th>
<th>ABSDIFF</th>
<th>RELDIFF</th>
<th>CPUTIME1 -&gt; CPUTIME2</th>
</tr>
</thead>
<tbody>
<tr>
<td>qemu-system-native</td>
<td>do_compile</td>
<td>-1597.2s</td>
<td>-76.3%</td>
<td>2093.6s -&gt; 496.4s</td>
</tr>
<tr>
<td>gcc-cross-x86_64</td>
<td>do_compile</td>
<td>-1397.8s</td>
<td>-79.3%</td>
<td>1763.1s -&gt; 365.3s</td>
</tr>
<tr>
<td>linux-yocto</td>
<td>do_compile</td>
<td>-1269.8s</td>
<td>-67.0%</td>
<td>1895.2s -&gt; 625.4s</td>
</tr>
<tr>
<td>cmake-native</td>
<td>do_compile</td>
<td>-1001.4s</td>
<td>-90.9%</td>
<td>1101.2s -&gt; 99.8s</td>
</tr>
<tr>
<td>linux-yocto</td>
<td>do_compile_kernelmodules</td>
<td>-954.9s</td>
<td>-65.3%</td>
<td>1462.8s -&gt; 507.9s</td>
</tr>
<tr>
<td>qemu-native</td>
<td>do_compile</td>
<td>-817.0s</td>
<td>-81.7%</td>
<td>1000.3s -&gt; 183.3s</td>
</tr>
<tr>
<td>binutils-cross-x86_64</td>
<td>do_compile</td>
<td>-493.7s</td>
<td>-80.6%</td>
<td>612.6s -&gt; 118.9s</td>
</tr>
<tr>
<td>binutils-native</td>
<td>do_compile</td>
<td>-449.5s</td>
<td>-56.4%</td>
<td>796.8s -&gt; 347.4s</td>
</tr>
<tr>
<td>cmake-native</td>
<td>do_configure</td>
<td>-416.0s</td>
<td>-84.9%</td>
<td>385.6s -&gt; 80.3s</td>
</tr>
<tr>
<td>gcc-runtime</td>
<td>do_compile</td>
<td>-305.3s</td>
<td>-79.2%</td>
<td>550.7s -&gt; 328.6s</td>
</tr>
<tr>
<td>perl</td>
<td>do_compile</td>
<td>-222.1s</td>
<td>-40.3%</td>
<td>239.9s -&gt; 36.7s</td>
</tr>
<tr>
<td>libdnf-native</td>
<td>do_install</td>
<td>55.9s</td>
<td>+98.7%</td>
<td>56.6s -&gt; 112.5s</td>
</tr>
<tr>
<td>python3</td>
<td>do_compile</td>
<td>160.5s</td>
<td>+13.7%</td>
<td>1175.2s -&gt; 1335.7s</td>
</tr>
<tr>
<td>openssl-native</td>
<td>do_compile</td>
<td>81.1s</td>
<td>-356.7s</td>
<td>1175.2s -&gt; 1335.7s</td>
</tr>
</tbody>
</table>

Cumulative cpu time:

```
-12419.0s  -40.8%  8:26:48.2 (30408.2s) -> 4:59:49.2 (17989.2s)
```
Average cputime (n = 15)

* p < 0.05

- do_compile
- do_compile_kemelmodules
- do_configure
- do_install
- other
- overall

- Without Icecream
- With Icecream
## Results (Wall Time)

### Without Icecream -> With Icecream

<table>
<thead>
<tr>
<th>PKG</th>
<th>TASK</th>
<th>ABSDIFF</th>
<th>RELDIFF</th>
<th>WALLTIME1 -&gt; WALLTIME2</th>
</tr>
</thead>
<tbody>
<tr>
<td>qemu-system-native</td>
<td>do_compile</td>
<td>-522.9s</td>
<td>-70.0%</td>
<td>747.4s -&gt; 224.5s</td>
</tr>
<tr>
<td>linux-yocto</td>
<td>do_compile_kernelmodules</td>
<td>-430.8s</td>
<td>-76.4%</td>
<td>563.7s -&gt; 132.8s</td>
</tr>
<tr>
<td>perl</td>
<td>do_install ptest base</td>
<td>-320.1s</td>
<td>-71.9%</td>
<td>445.5s -&gt; 125.4s</td>
</tr>
<tr>
<td>glibc-locale</td>
<td>do_package</td>
<td>-320.1s</td>
<td>-71.9%</td>
<td>622.4s -&gt; 302.3s</td>
</tr>
<tr>
<td>gcc-cross-x86_64</td>
<td>do_compile</td>
<td>-315.8s</td>
<td>-64.3%</td>
<td>490.9s -&gt; 175.1s</td>
</tr>
<tr>
<td>qemu-native</td>
<td>do_compile</td>
<td>-281.3s</td>
<td>-83.7%</td>
<td>336.1s -&gt; 54.8s</td>
</tr>
<tr>
<td>linux-yocto</td>
<td>do_kernel_configcheck</td>
<td>-277.0s</td>
<td>-79.8%</td>
<td>347.1s -&gt; 70.1s</td>
</tr>
<tr>
<td>cmake-native</td>
<td>do_compile</td>
<td>-262.0s</td>
<td>-70.1%</td>
<td>373.7s -&gt; 111.8s</td>
</tr>
<tr>
<td>gcc-runtime</td>
<td>do_configure</td>
<td>-201.8s</td>
<td>-50.9%</td>
<td>396.4s -&gt; 194.6s</td>
</tr>
<tr>
<td>libxml2</td>
<td>do_package</td>
<td>-201.1s</td>
<td>-82.0%</td>
<td>245.1s -&gt; 44.1s</td>
</tr>
<tr>
<td>libxcb</td>
<td>do_package_write_rpm</td>
<td>-176.3s</td>
<td>-62.5%</td>
<td>282.1s -&gt; 105.8s</td>
</tr>
<tr>
<td>gettext-native</td>
<td>do_configure</td>
<td>-175.0s</td>
<td>-43.3%</td>
<td>404.1s -&gt; 229.1s</td>
</tr>
<tr>
<td>gcc-runtime</td>
<td>do_compile</td>
<td>-172.4s</td>
<td>-80.1%</td>
<td>215.3s -&gt; 42.9s</td>
</tr>
<tr>
<td>nss-native</td>
<td>do_compile</td>
<td>-162.6s</td>
<td>-50.4%</td>
<td>322.5s -&gt; 159.8s</td>
</tr>
<tr>
<td>elfutils-native</td>
<td>do_configure</td>
<td>89.6s</td>
<td>+267.4%</td>
<td>33.5s -&gt; 123.1s</td>
</tr>
<tr>
<td>perl</td>
<td>do_package</td>
<td>123.7s</td>
<td>+44.6%</td>
<td>277.2s -&gt; 401.0s</td>
</tr>
<tr>
<td>shared-mime-info-native</td>
<td>do_install</td>
<td>135.0s</td>
<td>+238.0%</td>
<td>56.7s -&gt; 191.8s</td>
</tr>
<tr>
<td>binutils-native</td>
<td>do_install</td>
<td>171.9s</td>
<td>+172.0%</td>
<td>99.9s -&gt; 271.7s</td>
</tr>
<tr>
<td>glibc</td>
<td>do_install</td>
<td>206.9s</td>
<td>+64.8%</td>
<td>319.2s -&gt; 526.2s</td>
</tr>
<tr>
<td><strong>Cumulative walltime:</strong></td>
<td></td>
<td><strong>-9335.0s</strong></td>
<td><strong>-29.6%</strong></td>
<td><strong>8:46:07.8 (31567.8s) -&gt; 6:10:32.8 (22232.8s)</strong></td>
</tr>
</tbody>
</table>
Average walltime (n = 15)

* p < 0.05

- **walltime (seconds)**
  - do_compile
  - do_compile_kemelmodules
  - do_configure
  - do_install
  - other
  - overall

- **Legend**
  - Blue: Without Icecream
  - Red: With Icecream
Average Elapsed Build Time (n = 15)

- Average without Icecream: 5433.9
- Average with Icecream: 4369.1

Percent Change: -20%
Difference: -22%

Average CPU Usage (n = 15)

- Average without Icecream: 59.3%
- Average with Icecream: 37.3%

p < 0.05
## Results (Elapsed Time)

<table>
<thead>
<tr>
<th>ABSDIFF</th>
<th>RELDIFF</th>
<th>ELAPSED1 -&gt; ELAPSED2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elapsed time:</td>
<td>-1185.47s</td>
<td>-24.76%</td>
</tr>
<tr>
<td>CPU usage:</td>
<td>-19.7%</td>
<td>-29.40%</td>
</tr>
</tbody>
</table>

Elapsed time: 4787.41s -> 3601.94s
CPU usage: 67.0% -> 47.3%
Results (Per-task totals)

**do_configure:**
Cumulative cputime:
-341.1s   -9.8%   57:51.9 (3471.9s) -> 52:10.7 (3130.7s)
Cumulative walltime:
-1903.0s  -21.8%  2:25:48.8 (8748.8s) -> 1:54:05.8 (6845.8s)

**do_compile:**
Cumulative cputime:
-11284.6s -60.1%  5:13:08.1 (18788.1s) -> 2:05:03.5 (7503.5s)
Cumulative walltime:
-4202.6s  -47.0%  2:29:08.5 (8948.5s) -> 1:19:05.8 (4745.8s)

**do_install:**
Cumulative cputime:
13.2s     +1.4%   16:00.5 (960.5s) -> 16:13.7 (973.7s)
Cumulative walltime:
187.7s    +8.3%   37:47.4 (2267.4s) -> 40:55.1 (2455.1s)

**do_package_write_rpm:**
Cumulative cputime:
8.4s     +0.5%   28:54.3 (1734.3s) -> 29:02.7 (1742.7s)
Cumulative walltime:
-600.3s  -18.4%  54:14.8 (3254.8s) -> 44:14.5 (2654.5s)
Why use Icecream?

- Total elapsed build time reduction of 20%
- Computer is more responsive when building due to lower overall CPU usage
- Full rebuilds of individual recipes can be much faster
- It is free
Results Analysis

- Total build time performance improvement is marginal
  - Better system responsiveness when building
- Full rebuilds of individual recipes can be much faster
Outline

- What is Icecream?
- Why use Icecream?
- **How to use Icecream**
- Maximizing Performance
- What’s next
- Conclusion
How to enable Icecream?

Enabling Icecream is as easy(*) as adding the following to local.conf:

```
INHERIT += "icecc"
ICECC_PARALLEL_MAKE = "-j 24"
```
SDK Support

- Icecream also integrates with your traditional SDK
  - Building an SDK with `INHERIT += "icecc"` will automatically include support for Icecream
  - Icecream will be enabled for the SDK if the host has `icecc` when the SDK is installed

```bash
$ ./poky-glibc-x86_64-core-image-minimal-core2-64-qemux86-64-toolchain-2.7+snapshot.sh
Poky (Yocto Project Reference Distro) SDK installer version 2.7+snapshot
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Enter target directory for SDK (default: /opt/poky/2.7+snapshot):
You are about to install the SDK to "/opt/poky/2.7+snapshot". Proceed [Y/n]? y
Extracting SDK.............................done
Setting it up...done
Setting up IceCream distributed compiling...
creating /opt/.../poky-glibc-x86_64-x86_64-poky-linux-2.7+snapshot-20190722.tar.gz
SDK has been successfully set up and is ready to be used.
Each time you wish to use the SDK in a new shell session, you need to source the environment
setup script e.g.
$ . /opt/poky/2.7+snapshot/environment-setup-core2-64-poky-linux
```
Combining with sstate

- Get sstate working first
  - Icecream will never give as much benefit as a well populated sstate server

Problem: Icecream and sstate can be combined, however inheriting icecc.bbclass changes most taskhashes

Solution: Always inherit icecc.bbclass and use ICECC_DISABLED ?= “1” to turn off icecream
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Blacklisting

- Some massaging of `ICECC_USER_PACKAGE_BL` is necessary
  - There needs to be a better way to do this
- Blacklisting poorly performing recipes will help overall build time
Network Performance

- The test cluster has gigabit ethernet between all nodes
- Using 100 Mbps or less network speed is not likely to give good results
- Wi-Fi probably won’t work well either
Keep Up to Date with Upstream

- New versions of GCC generally requires updates to Icecream for bug fixes
- Upstream only releases about once a year
- Most of the changes are in the client side icecc shim and scheduler; the daemon is less important
- We build in a Docker container with a patched icecc shim
Use a dedicated scheduler

- The scheduler doesn’t take much CPU, but it is sensitive to latency
- Eliminates scheduler ping pong
- Easier to keep up to date
Avoid Virtual Machines

- Virtual Machines as compile nodes seem to be particularly bad for performance
  - Blacklist or mark as “No Remote”
Remote Preprocessing

- Icecream has the option of preprocessing remotely (ICECC_REMOTE_CPP), which improves performance even more
  - GCC has lots of issues related to “-fdirectives-only”, which currently makes this impractical in the general case.
    - [https://gcc.gnu.org/bugzilla/buglist.cgi?quicksearch=directives-only](https://gcc.gnu.org/bugzilla/buglist.cgi?quicksearch=directives-only)
Outline

● What is Icecream?
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● Maximizing Performance
● What’s next
● Conclusion
What’s Next?

- Build Icecream client shim in OE-core (e.g. icecc-native)?
- Clang support?
- ccache support?
- Gather more data from other clusters
- Fix up GCC’s -fdirectives-only support
- eSDK support
Outline

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Conclusion

- Icecream distributes jobs compiles with a centralized scheduler
- We saw a 20% build time improvement with Icecream
- There are many ways to get involved if you would like to improve the experience
- Try it yourself!
Useful Links

- [https://www.openembedded.org/wiki/Using_IceCC](https://www.openembedded.org/wiki/Using_IceCC)
- [https://github.com/icecc/icecream](https://github.com/icecc/icecream)
- Icecream Monitors:
  - [https://github.com/icecc/icemon](https://github.com/icecc/icemon)
  - [https://github.com/JPEWdev/icecream-sundae](https://github.com/JPEWdev/icecream-sundae) (shameless plug)
- Replicate my test:
  - [https://github.com/JPEWdev/oe-icecream-demo](https://github.com/JPEWdev/oe-icecream-demo)
Thanks

- Garmin
- Icecream Developers
- Open Emebedded Developers
- Kristin Watt, PhD
Questions?

I have a question.
Well, less of a question and more of a comment.
I guess it's less of a comment and more of an utterance.
Really it's less an utterance, more an air pressure wave.
It's less an air pressure wave and more a friendly hand wave.
I guess it's less a friendly wave than it is a friendly bug.
I found this bug and now we're friends. Do you want to meet it?

https://xkcd.com/2191/