Gentoo Prefix as a Physics Software Manager

Benda Xu (Tsinghua University), Guilherme Amadio (CERN), Fabian Groffen (Gentoo), Michael Haubenwallner (Gentoo)

https://www.gentoo.org

Nov. 5, 2019 CHEP’19 Adelaide
Sophisticated Analysis and Simulation

- Data analysis and detector simulation advance fast.
- Physics software stack is getting deeper.

Example (Pythia physics event generator)
Bundling dependencies all together is not elegant.
  ▶ Modularity is crucial for maintainability.

Package manager is the industry standard to solve this.
  ▶ It is invented by GNU/Linux distributions.

  the single biggest advancement Linux has brought to the industry.
Brace the Complexity

- Bundling dependencies all together is not elegant.
  - Modularity is crucial for maintainability.
- Package manager is the industry standard to solve this.
  - It is invented by GNU/Linux distributions.
    
    *the single biggest advancement Linux has brought to the industry.*

- Every GNU/Linux distribution has its package manager.

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**Example (Install the Z Shell)**

```
apt install zsh  #Debian
dnf install zsh   #Redhat
pacman -S zsh     #Archlinux
zypper install zsh #SUSE
emerge zsh         #Gentoo
```
Characteristics of Gentoo

- Full GNU/Linux distribution (2000–)
  - General purpose: from daily to scientific use cases.
  - Portability: x86, amd64, sparc, arm/64, alpha, mips, riscv, …
  - Meta-distribution: ultimate flexibility for specific needs.

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- **Community driven: spontaneous and distributed development.**
  - Packages, like the build recipe of Pythia, are shared pieces of wisdom of the community.

Example (`emerge -t pythia`)

- `[ebuild N ] sci-physics/pythia-8.2.26:8::gentoo`
- `[ebuild N ] sci-physics/hepmc-2.06.09-r1::gentoo`
- `[ebuild N ] sci-physics/lhapdf-6.2.3::gentoo`
- `[ebuild N ] dev-libs/boost-1.71.0:0/1.71.0::gentoo`
- `[ebuild U ] dev-util/boost-build-1.71.0::gentoo`
- `[ebuild N ] sci-physics/fastjet-3.0.6-r1::gentoo`
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```
Gentoo Package Manager for Physics

Gentoo Prefix installs a complete Gentoo userspace into a directory, called `${EPREFIX}`.

- Try it: download and run the bootstrap script

```bash
wget https://goo.gl/czXbjP -O bootstrap.sh
chmod +x bootstrap.sh
./bootstrap.sh
```

- Bootstrap has 3 Stages:
  1. Compile python and portage in `${EPREFIX}/tmp`.
  2. Install gcc in `${EPREFIX}/tmp` by portage.
  3. Build Gentoo in `${EPREFIX}` by portage and Stage 2 gcc.

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1https://wiki.gentoo.org/wiki/Project:Prefix

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Full GNU Userspace of Gentoo Prefix:

$ tree -L 1 -d

cvmfs/gentoo
|-- bin
| -- etc
| -- lib
| -- lib64
| -- run
| -- sbin
| -- tmp
| -- usr
`-- var

- ELF Program Headers INTERP points to dynamic loader in
  \($\mathtt{EPREFIX}\). Dynamic loader use libraries from \($\mathtt{EPREFIX}/lib\), etc.

\$ ldd `which cp`
  linux-vdso.so.1 (0x00007ffe245e2000)
  libacl.so.1 => /cvmfs/gentoo/usr/lib64/libacl.so.1 (0x00007f0f7ec29000)
  libc.so.6 => /cvmfs/gentoo/lib64/libc.so.6 (0x00007f0f7ea59000)
  /cvmfs/gentoo/lib64/ld-linux-x86-64.so.2 (0x00007f0f7ec59000)
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- Gentoo Prefix is a self-contained userspace,
  - Neither LD_LIBRARY_PATH nor ELF DT_RPATH is needed.
  - One Prefix runs on all: best distributed via cvmfs to
    heterogeneous GNU/Linux hosts, like CentOS, Ubuntu.
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- At the same time, it shares the global filesystem view, as opposed
  to filesystem namespaces/containers.
Inside Gentoo Prefix

- autotools-based build systems
  
  ```
  ./configure --prefix="${EPREFIX}" ...
  ```

- CMake-based build systems
  
  ```
  cmake -DCMAKE_INSTALL_PREFIX="${EPREFIX}" ...
  ```

- Python, Perl, R, Haskell packages inherit language interpreter directory prefix.

- Toolchain
  
  - `gcc`, `binutils` sysroot=${EPREFIX}, search for headers and libraries in EPREFIX.
  
  - `gcc` inject EPREFIX dynamic loader.
  
  - `glibc` look for configurations in EPREFIX/etc.

- Reference:
  
  `https://goo.gl/wQEkhE`

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Thanks to the flexibility of portage, other package formats can be straightforwardly converted into ebuilds. A few examples:

- **R CRAN**  Gentoo R-Overlay
- **Python PyPI**  Gentoo PyPI ebuild generator
- **Emacs ELPA**  Gentoo ELPA ebuild generator
- **Octave Forge**  Gentoo Octave overlay
- **Java Maven**  Gentoo Maven overlay (on-going)
- **Rust Cargo**  Gentoo Cargo ebuild generator (on-going)

Do not exist, you are welcomed to try :)  

- **Julia Pkg**  Gentoo Julia overlay...
Packages in Gentoo

- Big official package repository. cf. https://packages.gentoo.org
  /var/db/pkg $ ls -1 | grep ^sci
  sci-astronomy
  sci-biology
  sci-calculators
  sci-chemistry
  sci-electronics
  sci-geosciences
  sci-mathematics
  sci-physics
  sci-visualization

- R Overlay: 18993 packages, e.g. emerge ggplot2

- You can do anything on supercomputers:
  - Install the latest KDE (K Desktop Environment) suite.
  - Install your own slurm by Gentoo to distribute jobs.

- Life on the supercomputers made easier.
Case Study 1: Stone-Aged Computing Cluster

- Default environment is RHEL (Redhat Enterprise Linux) 5.

<table>
<thead>
<tr>
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Red Hat Enterprise Linux Server release 5.5 (Tikanga)

$ python -c "import sys; print sys.version"

2.4.3 (#1, Jun 11 2009, 14:09:37)

[GCC 4.1.2 20080704 (Red Hat 4.1.2-44)]

$ ld --version

GNU ld version 2.17.50.0.6-14.el5 20061020

Copyright 2005 Free Software Foundation, Inc.

$ ldd --version

ldd (GNU libc) 2.5

Copyright (C) 2006 Free Software Foundation, Inc.
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Case Study 1: Short Cut to Modern Age

- **Gentoo Prefix**: no restriction by the host OS:
  - **Python**
    
    ```bash
    $ python -c "import sys;print(sys.version)"
    3.6.6 (default, Aug 31 2018, 03:10:49)
    [GCC 8.2.0]
    ```
  - **Linker**
    
    ```bash
    $ ld --version
    GNU ld (Gentoo 2.30 p1) 2.30.0
    Copyright (C) 2018 Free Software Foundation, Inc.
    ```
  - **Dynamic loader**
    
    ```bash
    $ ldd --version
    ldd (Gentoo 2.19-r1 p3) 2.19
    Copyright (C) 2014 Free Software Foundation, Inc.
    ```

  `glibc-2.19` is the last glibc supporting `linux-2.6.18` of RHEL 5.
Case Study 2: Simultaneous Multiple Versions

- Stacked-Prefix can make thin instances based on a common one.

Example (Legacy of experimental physics)

- Coexistence of software suites to satisfy diverse requirements of varied scenarios.
- Quick deployment of arbitrary testing environments.
- Keeping Filesystem Hierarchy Standard (FHS) without needing containers.
Be an early adopter of arm64 supercomputing.

Works on all known rooted android devices.

Case Study Bonus

Gentoo on Android

- Be an early adopter of arm64 supercomputing.

Example (CERN)

- Managed as LCG releases
  
  $ /cvmfs/sft.cern.ch/lcg/contrib/gentoo/startprefix

Example (JUNO@IHEP)

- On lxslc7 login nodes
  
  $ /workfs/juno/xubd/gentoo/startprefix

- inode quota is not enough, and it is mounted by squashfs, unionfs and FUSE.
Conclusion

- Gentoo (1999–) has been the paradise for geek users and developers for decades.
  - From the community, but share the mindset of scientists.
- Gentoo portage is a feasible package manager for high energy physics.
  - It meets all the needs of us, and is especially good on cvmfs.
- The physics use case of Gentoo is a **natural consequence** of its flexibility and expertise in building operating systems.
  - Sustenable free ride on the developments outside science.

More information

- Homepage: [http://hep.tsinghua.edu.cn/~orv](http://hep.tsinghua.edu.cn/~orv)
  <heroxbd AT gentoo.com>
  <orv AT tsinghua.edu.cn>

Ebuild Example: ROOT

- Gentoo Ebuilds are written in carefully organized bash.
- [https://packages.gentoo.org/packages/sci-physics/root](https://packages.gentoo.org/packages/sci-physics/root)

```bash
# Copyright 1999-2019 Gentoo Authors
# Distributed under the terms of the GNU General Public License v2

EAPI=6

# ninja does not work due to fortran
CMAKE_MAKEFILE_GENERATOR=emake
FORTRAN_NEEDED="fortran"
PYTHON_COMPAT=( python2_7 python3_5 python3_6 )

inherit cmake-utils eapi7-ver elisp-common eutils fortran-2 \
    prefix python-single-r1 toolchain-funcs

DESCRIPTION="C++ data analysis framework and interpreter from CERN"
HOMEPAGE="https://root.cern"
SRC_URI="https://root.cern/download/${PN}_v${PV}.source.tar.gz"
```

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