TEXAS ADVANCED COMPUTING CENTER

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The University of Texas at Austin

XALT: Job-Level Usage Data on Today's Supercomputers.

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XALT: Outline

XALT

- What is XALT and what it is not?
- Brief History
- How it works: Three Parts
- What can you do with it?
- How can I help you?

Understanding what your users are doing

- What programs, libraries are your users using?
- What imports from R, MATLAB, Python?
- What are the top programs by core-hours? by counts? by users?
- System, User or Built by Other executables?
- Are Executables implemented in C/C++/Fortran?
- Track MPI task and/or Threading ($OMP_NUMTHREADS)
- Function Tracking
- Census Taker, Not a performance tool!

Brief History

- XALT was an U.S. NSF funded project (M. Fahey & R. McLay)
- Work continued at TACC: too useful
- Originally only tracked MPI execution.

Design Goals

- Be extremely light-weight
- How many use a library or application?
- What functions are users calling in system modules
- Collect Data into a Database for analysis.

How does XALT work?

- LD Wrapper
- ELF Trick to track execution
- Signal handling
- Generate Json records
- Transport to DB
- Analyze database.

Design: LD Wrapper

- XALT wraps the linker to enable tracking of exec's
- The linker (ld) wrapper intercepts the user link line.
- Generate assembly code: key-value pairs
- Capture tracemap output from ld
- Transmit collected data in *.json format
- Optionally add codes that executes before main() and after main() completes for static builds.

Signal handling

- XALT registers signal handlers before main()
- SIGSEGV, SIGFPE, SIGTERM, etc
- User code can override with their own.

Elf Trick (I)

- ELF is the binary format for Linux
- ELF has many hooks
- XALT uses two hooks to run before/after main()

ELF Trick (II)

```
#include <stdio.h>
void myinit(int argc, char **argv)
{ fprintf(stderr, "This is run before main()\n"); }
void myfini()
{ fprintf(stderr,"This is run after main()\n");}
static __attribute__((section(".init_array")))
     typeof(myinit) *__init = myinit;
static __attribute__((section(".fini_array")))
     typeof(myfini) *__fini = myfini;
```

ELF Trick (III)

```
% LD_PRELOAD=./libxalt.so ./hello
This is run before main()
Hello World!
This is run after main()
```

Transmission to DB

- File: collect nightly/hourly/...
- Syslog: Use Syslog filtering (or ELK)
- Curl: send directly

Lmod to XALT connection (I)

- Optional support to connect paths to modules
- Lmod spider walks entire module tree.
- Can build a reverse map from paths to modules
- Can map program & libraries to modules.
- /opt/apps/i15/mv2_2_1/phdf5/1.8.14/lib/libhdf5.so.9 $\Rightarrow$ phdf5/1.8.14(intel/15.02:mvapich2/2.1)
- Also helps with function tracking.
- Tmod Sites can still use Lmod to build the reverse map.

Lmod to XALT connection (II)

- Need XALT's ld before compiler's ld
- User loads a new compiler module?
- Lmod support path priority:
- `prepend_path{"PATH", "/.../xalt/bin", priority = 100}`

Lmod path priority (I)

```
$ type -a ld
ld is /opt/apps/xalt/xalt/bin/ld
ld is /opt/apps/gcc/8.3.0/bin/ld
ld is /bin/ld
```

Lmod path priority (II)

```
$ module load gcc/9.1.0; type -a ld
ld is /opt/apps/xalt/xalt/bin/ld
ld is /opt/apps/gcc/9.1.0/bin/ld
ld is /bin/ld
```

XALT LD Wrapper Support w/o Lmod

- Move Compiler's ld to ld.x
- Small change in XALT's ld to find ld.x
- Must do this for every new compiler install.
- Or put xalt's bin path before compiler path in module
- Or treat every executable like `ls` or ABAQUS

Installing XALT

- Easy: `./configure ...; make install`
- Harder: Reverse Map from Lmod?
- Harder: Site config.py file
- Harder: Setup Transport Json records
- Harder: Setup VM to hold database
- Or: Setup your own way to handle the data

Site config.py (I)

- Each site must configure to match their setup
- Compute node names?
- What executables to track or ignore?
- What python packages to track or ignore?
- What sampling rules to use?

Site config.py (II)

- XALT use config.py to create *.h, *.lex *.py files during build.
- Provides xalt_configuration_report C++ program to know how configured.
- Config.py file only used when building XALT.
- Any changes to Config.py require a re-install of XALT.

Hostname, Path and Env Filtering

- Uses FLEX to compile in patterns
- Use regex expression to control what to keep and ignore.
- These Flex $\Rightarrow$ C routine provide fast regex parsing.

TACC_config.py

```
hostname_patterns = [
  ['KEEP', '^c[0-9][0-9][0-9]-[0-9][0-9][0-9]\..*']
  ['KEEP', '^nid[0-9][0-9][0-9][0-9][0-9].*']
]
path_patterns = [
    ['PKGS',  r'.*\/python[0-9.]*'],
    ['PKGS',  r'.*\/R'],
    ['KEEP',  r'^/\usr\/bin\/ddt'],
    ['SKIP',  r'^\/bin\/.*'],
]
env_patterns = [
    [ 'SKIP', r'^MKLROOT=.*' ],
    [ 'SKIP', r'^MKL_DIR=.*' ],
    [ 'KEEP', r'^I_MPI_INFO_NUMA_NODE_NUM=.*'],
]
```

How sampling works

- Changed design to deal with the overload of XALT data
- Only generate records if plan to save.
- All Non-mpi executions only produce end records.
- Small MPI execution sample, Large MPI executions record.

Sampling Non-MPI programs

- XALT has sampling rules (site configurable!)
- TACC rules are:
- 0 mins $<$ 30 mins $\Rightarrow$ 0.01% recorded
- 30 mins $<$ 120 mins $\Rightarrow$ 1% recorded
- 120 mins $<$ ∞ $\Rightarrow$ 100% recorded
- Can now track/sample perl, awk, sed, gzip etc

Sampling MPI programs

- Some users are using many short MPI programs to train Deep Learning engine
- TACC rules are:
- Task counts $<$ 128 tasks are sampled
  - 0 mins $<$ 15 mins $\Rightarrow$ 0.01% recorded
  - 15 mins $<$ 30 mins $\Rightarrow$ 1% recorded
  - 30 mins $<$ ∞ $\Rightarrow$ 100% recorded
- Task counts $>=$ 128 task are always recorded independent of runtime.
- Need to Capture long running MPI progs that never end.

Using XALT Data

- Targeted Outreach: Who will be affected
- Largemem Queue Overuse
- XALT and TACC-Stats
- Who is running NWChem or ...?
- Function Tracking: Who or What is using MPI-3?

Who is using MPI-3: MPI_I*

What codes link in MPI-3 routines. (Not necessarily Run)

Function Name	N Users	N Progs
MPI_Ibarrier	8	4
MPI_Ialltoall	24	4
MPI_Ineighbor_alltoall	4	3

What is new with XALT?

- Tracking R, Python, MATLAB
- Signal handler
- Optionally Track GPU Usage
- Track Singularity Container Usage
- Removed three system calls for improved speed
- `xalt_configuration_report`

Tracking R packages

- XALT can now track R package usage
- James McComb & Michael Scott from IU developed the R part
- They do this by intercepting the “imports”

Tracking Python packages

- Help from Riccardo Murri
- sitecustomize.py
- It is run by any Python if found.
- All Pythons uses sys.meta_path to locate files to import
- Can register object to capture imports.
- Just add location to PYTHONPATH

Filtering python packages

```
{ 'k_s':'SKIP','kind':'path','patt': r"^[^/]" },
{ 'k_s':'SKIP','kind':'name','patt': r"^_"    },
{ 'k_s':'SKIP','kind':'name','patt': r".*\." },
{ 'k_s':'KEEP','kind':'path','patt': r".*/.local/" },
```

New program: xalt_extract_record

- This program reads the watermark.
- Find out who built this program on what machine
- Find out what modules where used.
- Where was it build.

Example of xalt_extract_record output

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
XALT Watermark: hello
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
Build_CWD                /home/user/t/hello
Build_Epoch              1510257139.4624
Build_LMFILES      /apps/mfiles/intel/17.0.4.lua:...
Build_LOADEDMODULES intel/18.0.4:impi/18.0.3:TACC:..
Build_OS           Linux 3.10.0-514.26.2.el7.x86_64
Build_Syshost            stampede2
Build_UUID                  586d5943-67eb-480b-a2fe-
35e87a1f22c7
Build_User               mclay
Build_compiler           icc
Build_date               Fri Jun 09 13:52:19 2019
Build_host          c455-011.stampede2.tacc.utexas.edu
XALT_Version             2.7
```

New Feature: Track GPU usage

- Optionally, XALT can know if a GPU was used.
- XALT will only know if one or more GPU's were accessed
- No performance data
- Thanks to Scott McMillan from NVIDIA for the contribution.

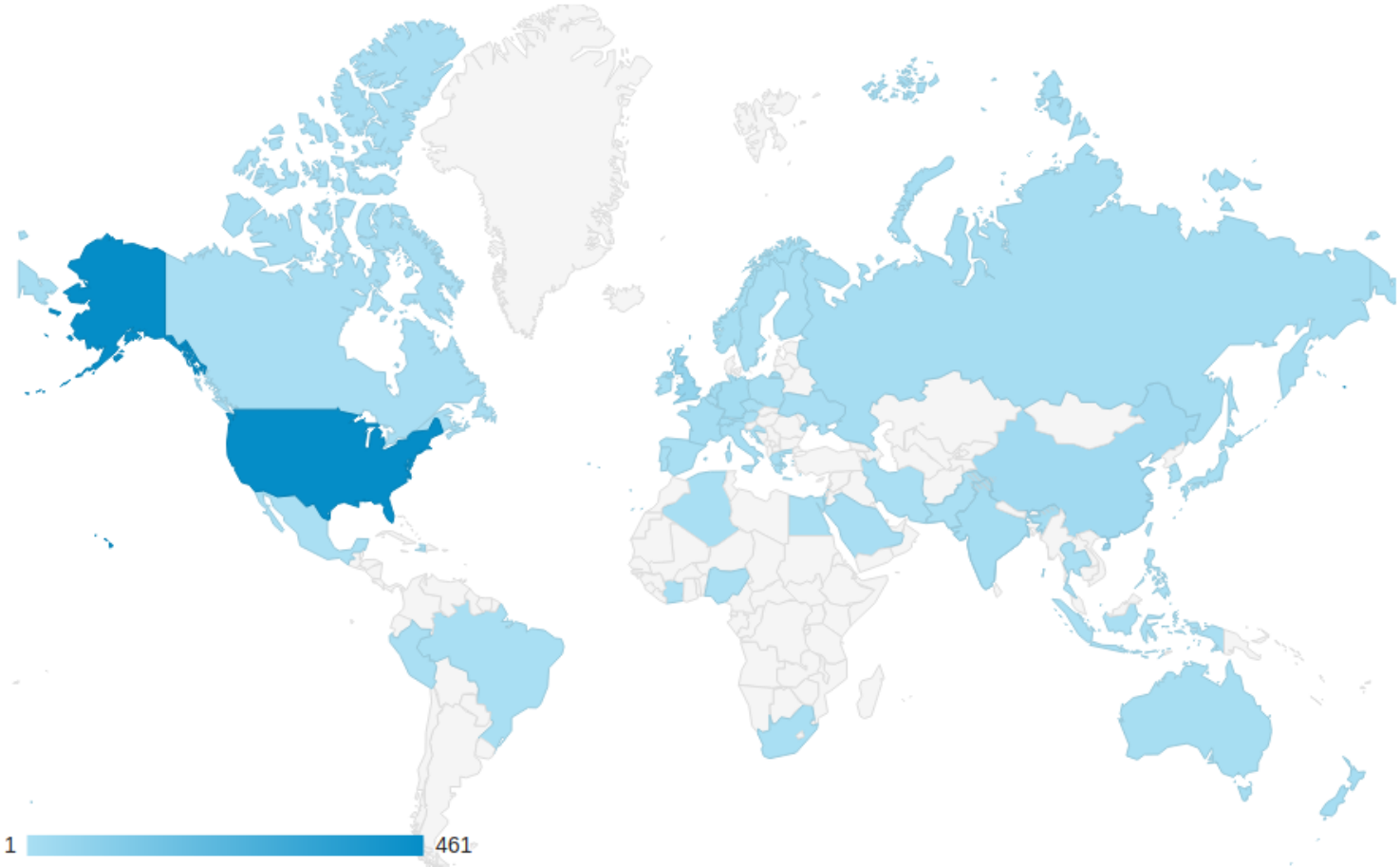
New Feature: Track Singularity Container Usage

- Sites can configure their Singularity script to include XALT
- It works well with syslog, file or curl transfer of data
- Thanks to Scott McMillan from NVIDIA for the contribution.

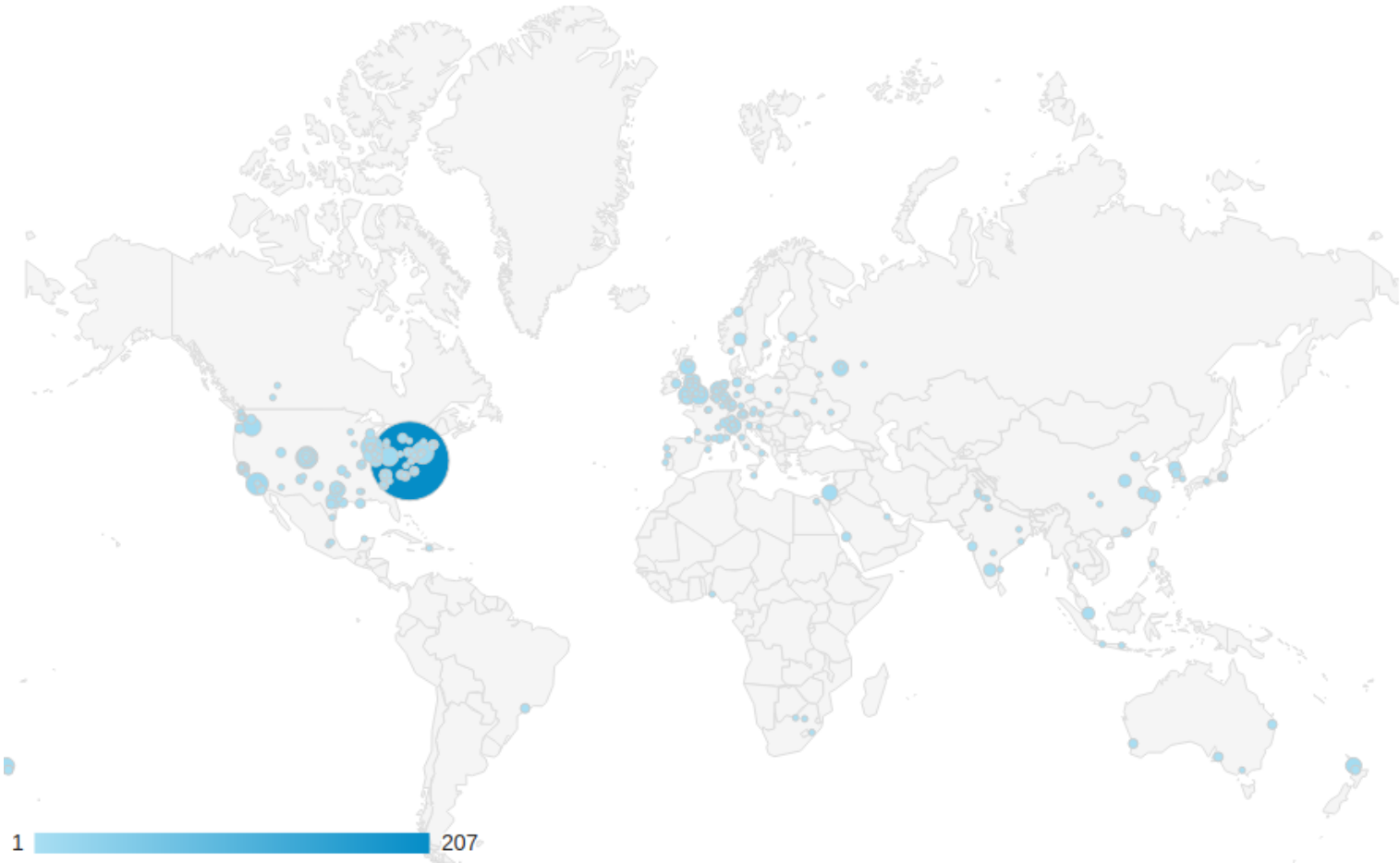
Debugging XALT

```
$ XALT_TRACING=yes XALT_SAMPLING=no ./hello

myinit(0/1,LD_PRELOAD,/path/to/hello){
    -> Setting up signals
    -> Leaving myinit
}

Hello World!

myfini(0/1,LD_PRELOAD,/path/to/hello){
    -> XALT_SAMPLING = "no" All programs tracked!
  Recording State at end of scalar user program:
    XALT_EXECUTABLE_TRACKING=no /path/to/xalt_run_submission ...

  xalt_run_submission(.zzz) {
    building UUID: ...
    Extracted recordT from executable
    Built userT, userDT, scheduler: SLURM
    Using XALT_TRANSMISSION_STYLE: file
    cmdlineA: ["./hello"]
    Built json string
  }
    -> leaving myfini
}
```

XALT Doc usage by Country



XALT Doc usage by City



Conclusion

- Lmod:
  - Source: github.com/TACC/lmod.git, lmod.sf.net
  - Documentation: lmod.readthedocs.org
- XALT:
  - Source: github.com/xalt/xalt.git, xalt.sf.net
  - Documentation: XALT 2 $\Rightarrow$ xalt.readthedocs.org
  - Join mailing list: https://sourceforge.net/projects/xalt/lists/xalt-users