Current state of the Userspace Tracer (UST)

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Who am I

- B.sc in Computer Science at Université de Sherbrooke (Québec, CA)
- Worked at Revolution Linux for the last 2 years as an infrastructure analyst
- **Now,** Graduate Student at Polytechnique de Montréal with Prof. Michel Dagenais

- Reasearch subject :
  - *Efficient tracing for large scale systems using UST*

REVOLUTION
LINUX
www.revolutionlinux.com

- Services and Consulting
- Large Scale Infrastructure
- Thin Client / Applications Server
- All open source software and Linux

For us, **tracing** with low overhead
is the name of the game

Quick Overview

Basic Functionality

Use Case

Performance

Future Work

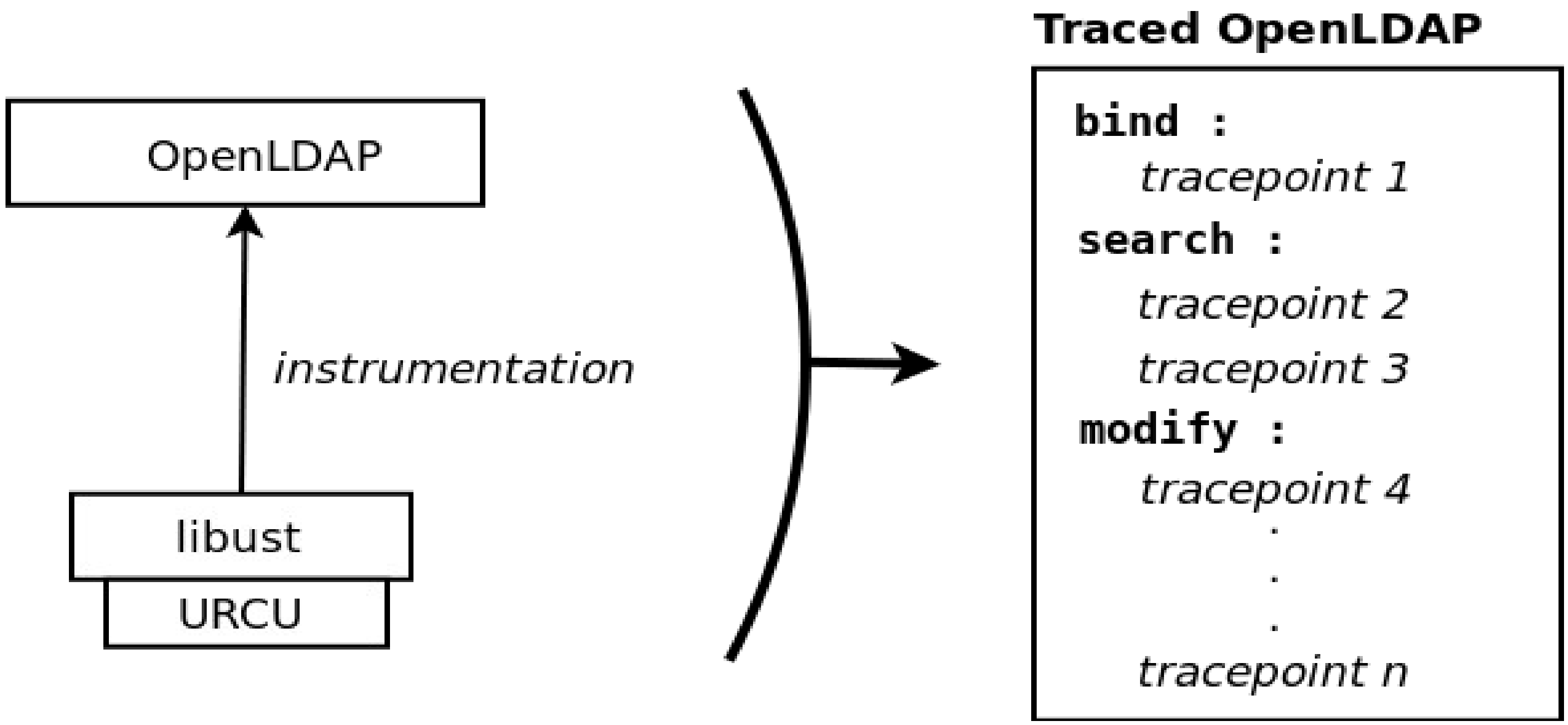
1. Overview (1 of 3)

What is UST ?

- Userland tracing
- Low overhead tracer
- Build with LTTng technology
- LTTV or/and TMF trace viewer
- Written by Pierre-Marc Fournier at Polytechnique

  - ➢ How userspace tracing is achieved with UST ?

1. Overview (2 of 3)



- *Ex: instrument with tracepoints **bind**, **search** and **modify** requests*

1. Overview (3 of 3)

- Core code is mostly from LTTng
  - Lockless tracer (ring buffer) (Mathieu Desnoyers)
  - Userspace RCU (Paul E. Mckenney and Mathieu Desnoyers)
- Tools for tracing :
  - *ustd :* daemon for collecting data
  - *usttrace :* script for trace start up
  - *ustctl* : control the tracing

Quick Overview

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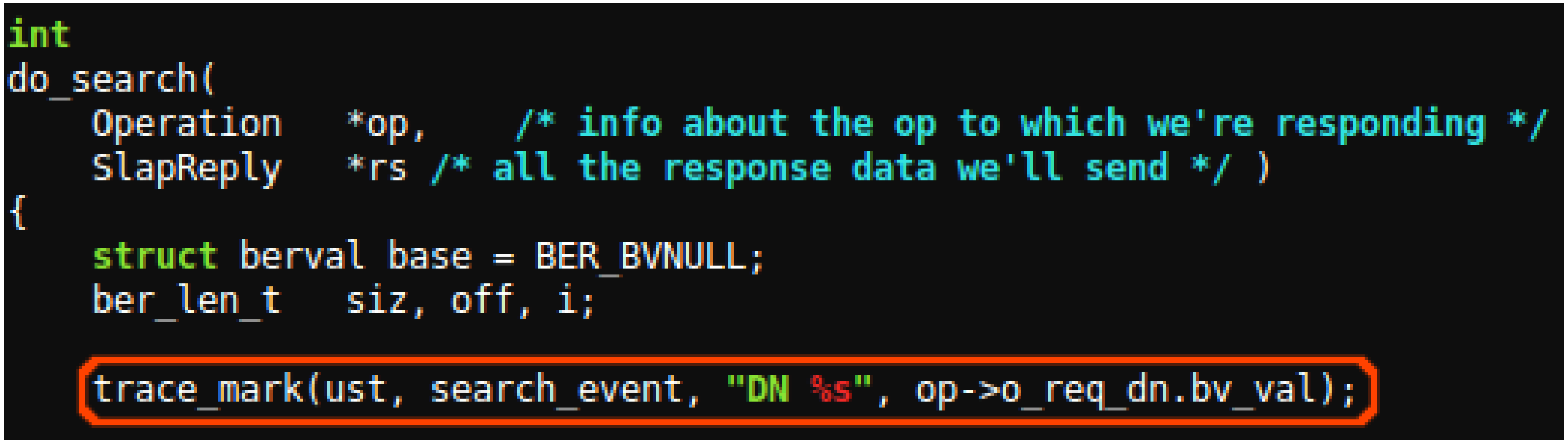
2. Basic Functionality

2.1 Instrumentation (1 of 3)

- Using *Markers*

servers/slapd/search.c



```
int
do_search(
    Operation   *op,    /* info about the op to which we're responding */
    SlapReply   *rs /* all the response data we'll send */ )
{
    struct berval base = BER_BVNULL;
    ber_len_t   siz, off, i;

    trace_mark(ust, search_event, "DN %s", op->o_req_dn.bv_val);
```

```
# ldapsearch -b “dc=rlnx,dc=com” ...
```

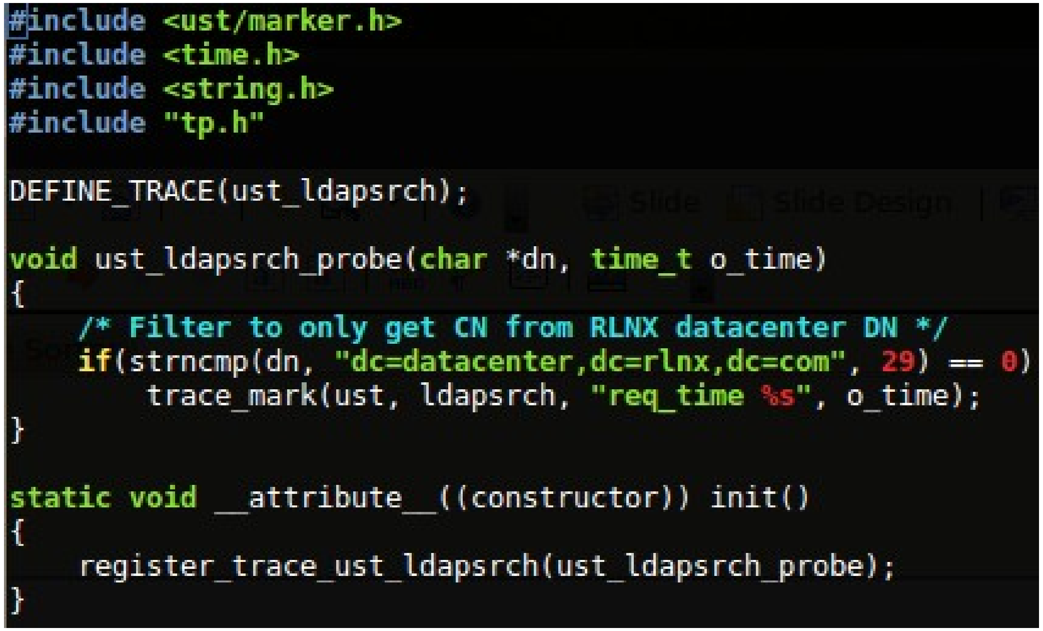
Output --> { “DN” = “`dc=rlnx,dc=com`” }

2. Basic Functionality

2.1 Instrumentation (2 of 3)

- Using *Tracepoints*

servers/slapd/tp.c (NEW)



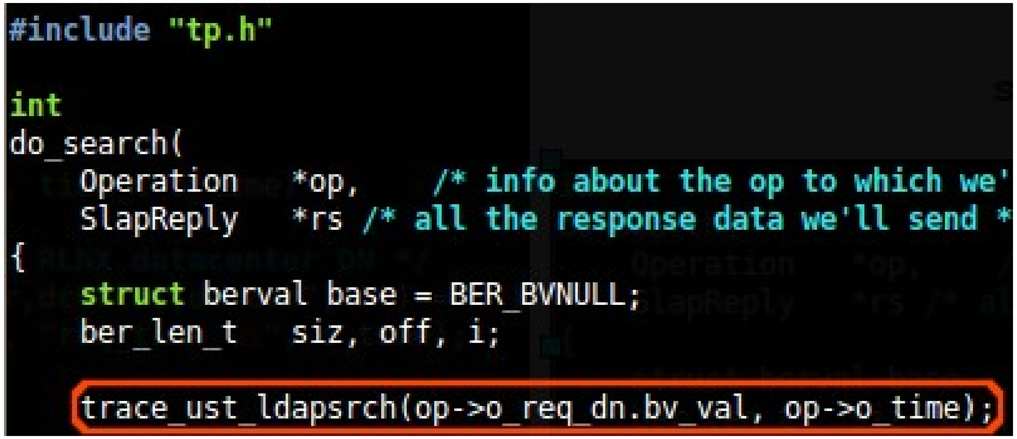
```
#include <ust/marker.h>
#include <time.h>
#include <string.h>
#include "tp.h"

DEFINE_TRACE(ust_ldapsrch);

void ust_ldapsrch_probe(char *dn, time_t o_time)
{
    /* Filter to only get CN from RLNX datacenter DN */
    if(strncmp(dn, "dc=datacenter,dc=rlnx,dc=com", 29) == 0)
        trace_mark(ust, ldapsrch, "req_time %s", o_time);
}

static void __attribute__((constructor)) init()
{
    register_trace_ust_ldapsrch(ust_ldapsrch_probe);
}
```

servers/slapd/search.c

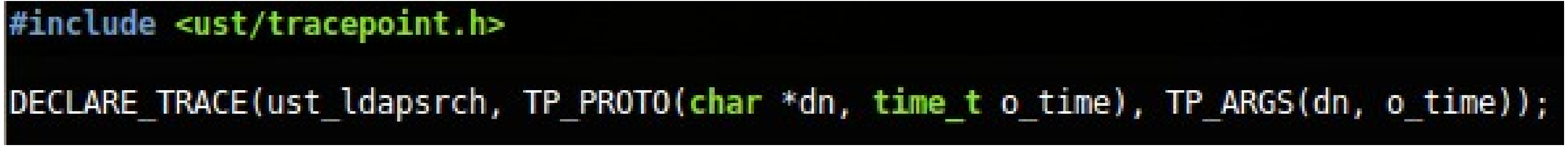


```
#include "tp.h"

int
do_search(
    Operation   *op,    /* info about the op to which we'
    SlapReply   *rs /* all the response data we'll send *
{
    struct berval base = BER_BVNULL;
    ber_len_t   siz, off, i;

    trace_ust_ldapsrch(op->o_req_dn.bv_val, op->o_time);
```

servers/slapd/tp.h (NEW)



```
#include <ust/tracepoint.h>

DECLARE_TRACE(ust_ldapsrch, TP_PROTO(char *dn, time_t o_time), TP_ARGS(dn, o_time));
```

2. Basic Functionality

2.1 Instrumentation (3 of 3)

- What can be instrumented ?
  - Multi-threaded applications
  - Signal Handlers
  - Shared Libraries

Programs must be compile with **libust (-l ust)**

Also, `LD_PRELOAD=/usr/local/lib/libust.so.0` if some part of the app **is** instrumented (Ex: dynamic libraries) but not the main app.

2. Basic Functionality

2.2 LD_PRELOAD (1 of 2)

- What if we can't instrument ?
  - Old application (difficult to recompile)
  - Instrumentation MAY be too much work

Solution :

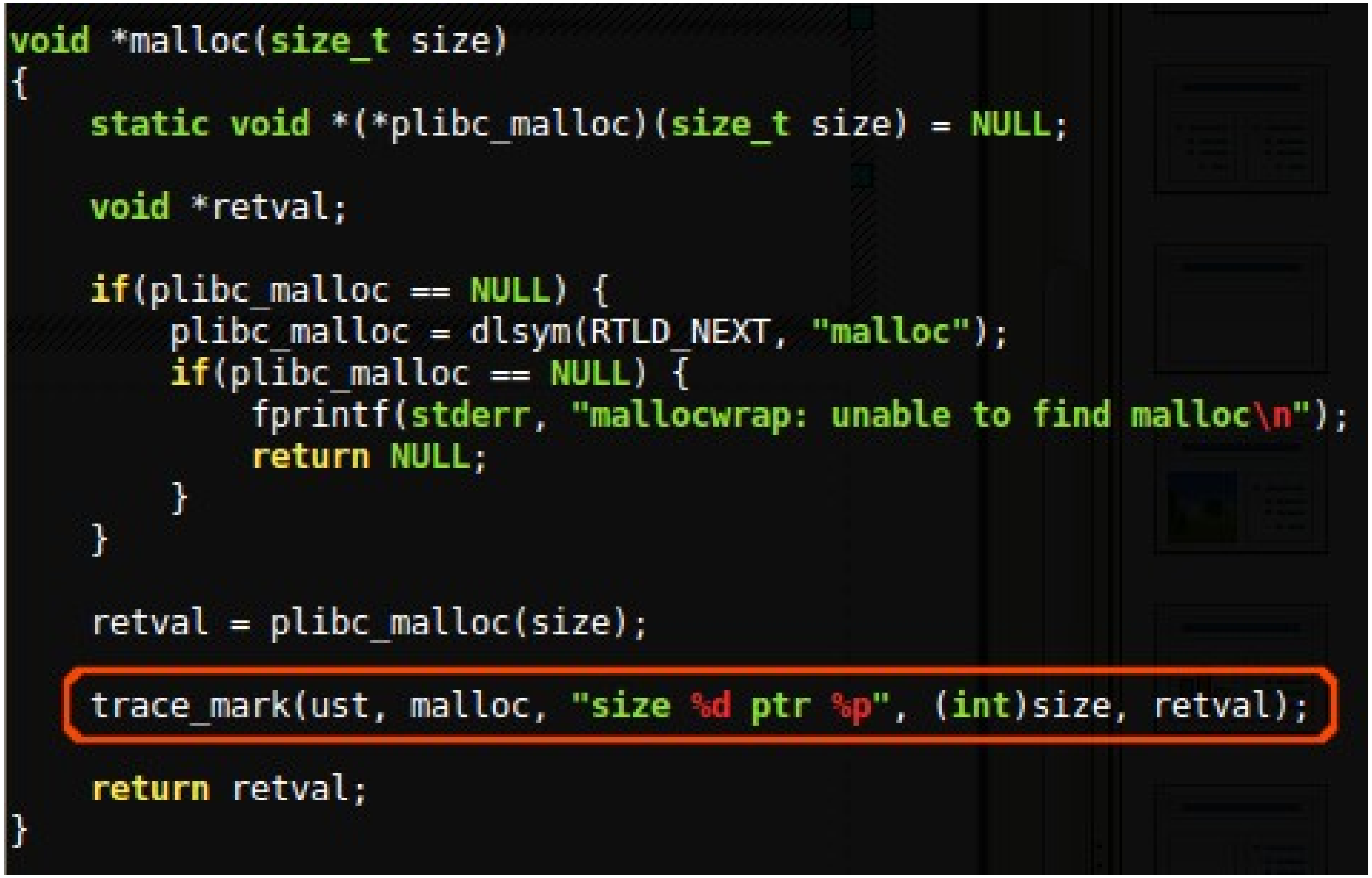
```
# gcc -fpic -shared -ldl -lust -O2 -o libldaptrace.so CODE.c
# LD_PRELOAD=./libldaptrace.so ./slapd
```

* But only for linked symbols

2. Basic Functionality

2.2 LD_PRELOAD (2 of 2)

- **`malloc`** example



```
void *malloc(size_t size)
{
    static void *(*plibc_malloc)(size_t size) = NULL;

    void *retval;

    if(plibc_malloc == NULL) {
        plibc_malloc = dlsym(RTLD_NEXT, "malloc");
        if(plibc_malloc == NULL) {
            fprintf(stderr, "mallocwrap: unable to find malloc\n");
            return NULL;
        }
    }

    retval = plibc_malloc(size);

    trace_mark(ust, malloc, "size %d ptr %p", (int)size, retval);

    return retval;
}
```

2. Basic Functionality

2.3 Tools (1 of 3)

- ***`ustd(1)`***
  - Collects trace data
  - Writes that data to disk

Communication : **traced app <-> ustd**

→ Unix Socket : **`/tmp/ust-app-socks/PID`**

2. Basic Functionality

2.3 Tools (2 of 3)

- ***`ustctl(1)`***
  - Control the tracing of userspace apps.
  - create/alloc/start/stop/destroy a trace
  - enable/disable/list markers
  - set/get subbuffers info

2. Basic Functionality

2.3 Tools (3 of 3)

- ***usttrace(1)***
  - Script tool for trace recording

1. Creates a daemon
2. Enables all markers
3. Runs the command
4. At the end, prints the location of the trace

```
# usttrace ./slapd
[...]
Waiting for ustd to shutdown...
Trace was output in:  /home/dave/.usttraces/raoul-20100805143324547483745
```

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3. Use Case (1 of 3)

- We've instrumented OpenLDAP
  - ldap_seach
    - `trace_mark(ust, ldap_search, “Filter %s”, filter.var)`
  - ldap_modify
    - `trace_mark(ust, ldap_modify, “CN %s”, cn.var)`
  - ldap_bind
    - `trace_mark(ust, ldap_bind, “DN %s”, userdn.var)`

3. Use Case (2 of 3)

1. Launch OpenLDAP normally

```
# /etc/init.d/slapd (PID : 1234)
```

2. **Setup** the trace

```
# ustd
# ustctl --enable-marker ust/ldap_search 1234
# ustctl --create-trace 1234
```

3. **Start** the trace

```
# ustctl --start-trace 1234
```

4. Enable a second marker

```
# ustctl --enable-marker ust/ldap_modify 1234
```

3. Use Case (3 of 3)

5. Stop the trace

```
# ustctl --stop-trace 1234
# ustctl --destroy-trace 1234
```

6. View the trace with **lttv/tmf**

```
# ls /tmp/usttrace/1234_5502332342922775910
.   metadata_0  metadata_2  metadata_4  metadata_6  ust_0  ust_2  ust_4  ust_6
..  metadata_1  metadata_3  metadata_5  metadata_7  ust_1  ust_3  ust_5  ust_7
```

- lttv-gui or Eclipse TMF

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4. Performance (1 of 4)

Who cares about tracing in *userland* ?

Good debug for a lots of large apps :

- Apache, LDAP, Samba, etc

4. Performance (2 of 4)

1. **Flexibility**
   - Enable what marker you want... at any time!
   - Granularity
2. Synchronization
   - Buffer protected
   - Program crashes, data still available

4. Performance (4 of 4)

3. Signal Safe
4. Scalability
   - Multithreaded applications
5. Low-intrusiveness
   - Applications normal behaviour not changed
   - Block signal for listener thread

4. Performance (3 of 4)

- Quick look at performance
  - **`trace_mark`** :
    - ~ 247 ns / per event
  - **`tracepoint + trace_mark`** :
    - ~ 271 ns / per event
  - **`tracepoint + custom_probe`** :
    - ~ 189 ns / per event

1000 iterations
5 000 000 events
1 thread

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5. Future Work

- Session tracing
- Time sync with Kernel (vdso?)
- **`TRACE_EVENT`** integration
- UST streaming : TCF (almost there)
- Event filtering (Nils Carlson @ Ericsson)

Questions ?