Linux Plumbers Conference
Tracing Summit 2012

Interoperability Between Tracing Tools with the Common Trace Format (CTF)

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> Presenter

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> Content

- Common Trace Format introduction & goals
- Trace Stream Description Language
- Overview of trace layout
- Collaboration
- Reference implementations
- Other tools based on CTF
- Areas to improve
- Conclusion

> Common Trace Format

- Targets system-wide and multi-system trace representation in a common format, for integrated analysis:
  - Software traces
    - Across multiple CPUs
    - Across the software stack (Hypervisor, kernel, library, applications)
  - Hardware traces
    - DSPs, device-specific tracing components.
    - GPUs.

> Goals of the Common Trace Format (CTF)

- Portable,
- Compact,
- Configurable per-architecture to express layout required for speed,
- Transport independent: disk, network, serial port, memory,
- Usable on minimalistic DSPs as well as full-featured OS,
- Availability of flight recorder,

> Goals of the Common Trace Format (CTF) (continued)

- Buffers retrievable after crash,
- Support dynamically inserted instrumentation while tracing,
- Support per-cpu buffers, and many configurable streams.

> What is CTF ?

- Self-described binary trace format
- Domain-specific language (DSL) for description of stream layout: TSDL (Trace Stream Description Language)
- Trace embeds its own description

> TSDL Trace Description

- TSDL trace description entry:

```
trace {
	major = 1; minor = 8; uuid = "a116db0a-ad45-40a0-9f66-b195d79432a0";
	byte_order = le;
	packet_header := struct {
		uint32_t magic; uint8_t  uuid[16]; uint32_t stream_id;
	 };
};
```

> TSDL Clock Description

- TSDL clock description entry:

```
clock {
        name = monotonic;
        uuid = "1fece6ff-a288-4a59-b750-07bef0d296f0";
        description = "Monotonic Clock";
        freq = 1000000000; /* Frequency, in Hz */
        /* clock value offset from Epoch is: offset * (1/freq) */
        offset = 1338755739325858212;
};

typealias integer {
        size = 64; align = 8; signed = false;
        map = clock.monotonic.value;
} := uint64_clock_monotonic_t;
```

> TSDL Types

- TSDL type descriptions:

```
typealias integer { size = 64; align = 8; signed = false; } := uint64_t;
[...]
typealias integer { size = 27; align = 1; signed = false; } := uint27_t;
struct packet_context {
        uint64_clock_monotonic_t timestamp_begin;
        uint64_clock_monotonic_t timestamp_end;
        uint32_t events_discarded; uint32_t content_size; uint32_t packet_size;
        uint32_t cpu_id;
};
struct event_header {
        uint64_t timestamp;
        uint32_t id;
} align(8);
```

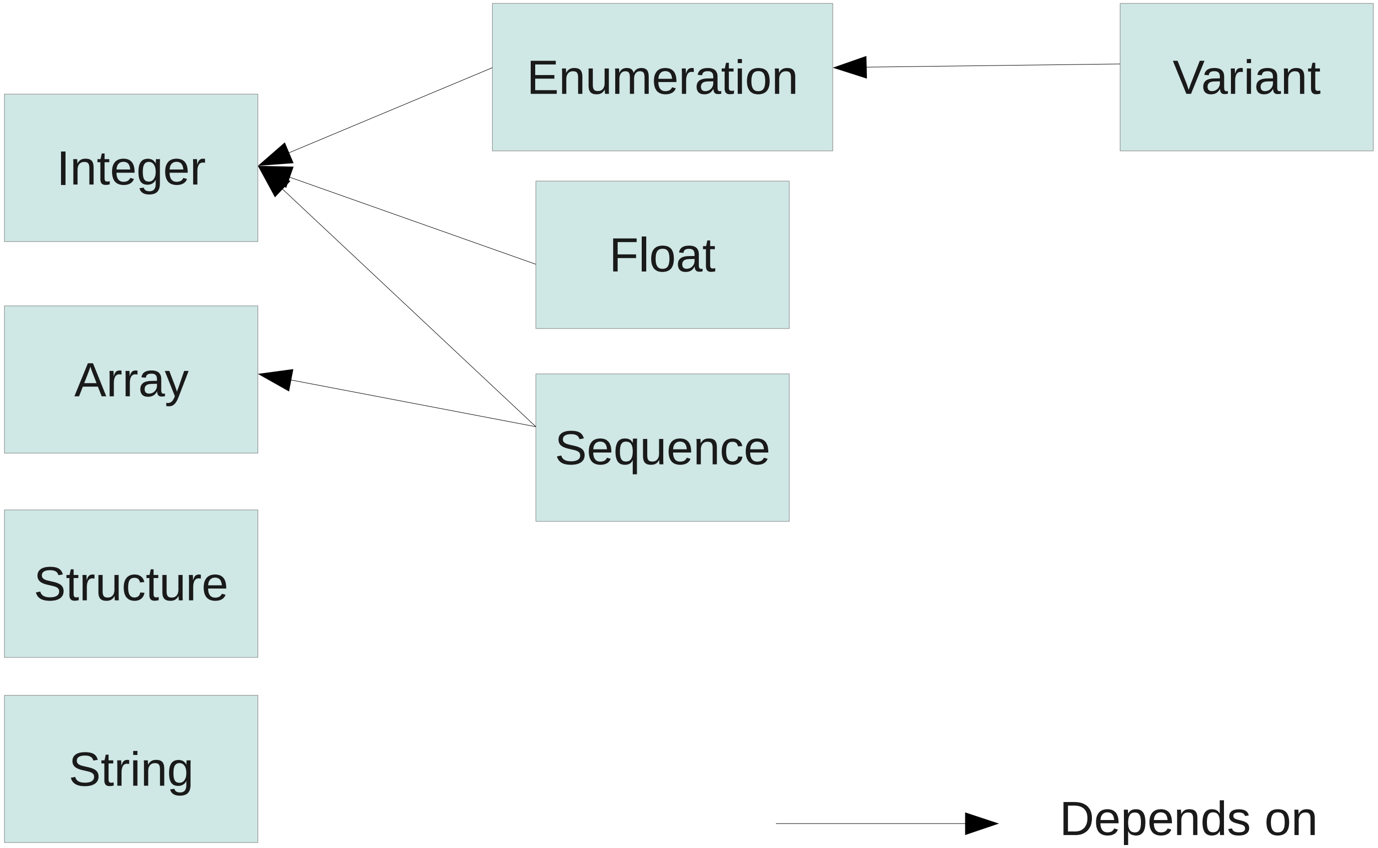
> TSDL Stream and Event

- TSDL stream and event descriptions:

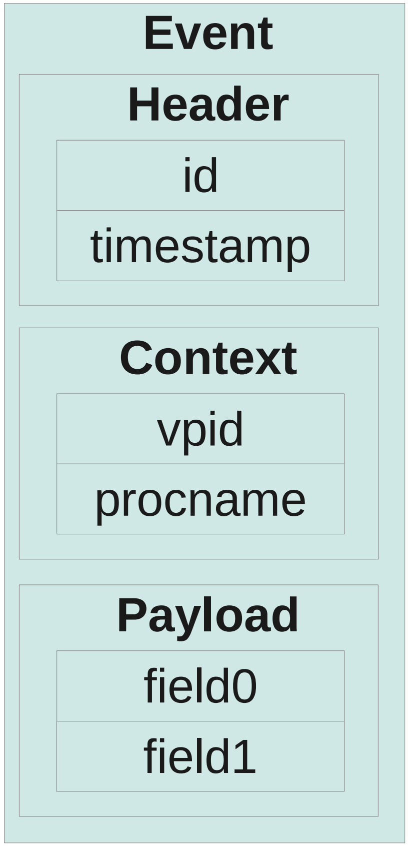
```
stream {
        id = 0;
        event.header := struct event_header;
        packet.context := struct packet_context;
};

event {
        name = "ust_tests_hello:tptest"; id = 0; stream_id = 0; loglevel = 13;
        fields := struct { uint27_t _intfield; [...] };
};
```

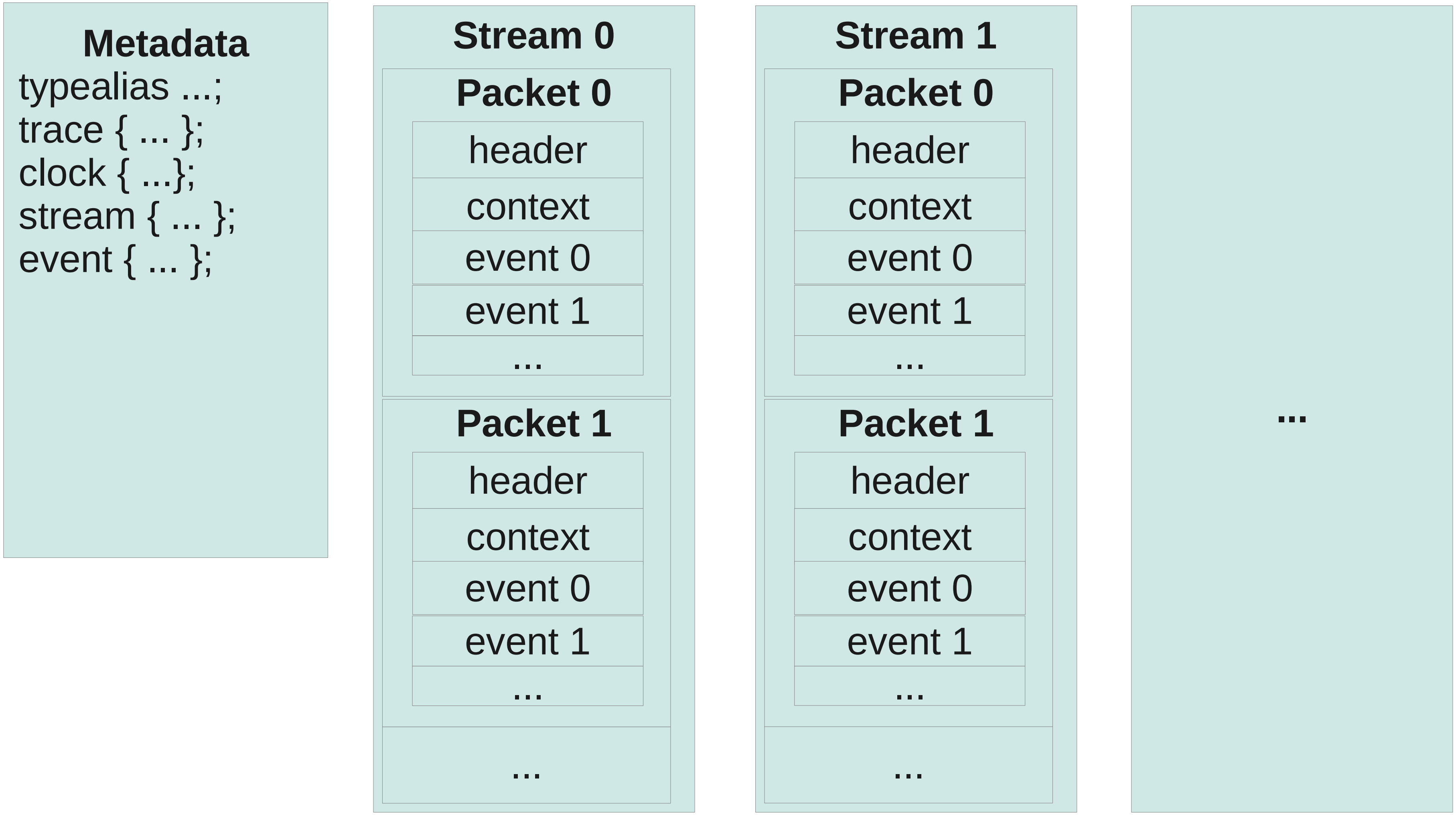
> CTF Diagram: Field Types



> CTF Diagram: Event Structure Example



> CTF Diagram: Trace Structure



Metadata

```
typealias ...;
trace { ... };
clock { ...};
stream { ... };
event { ... };
```

Stream 0

Packet 0

header

context

event 0

event 1

...

Packet 1

header

context

event 0

event 1

...

...

Stream 1

Packet 0

header

context

event 0

event 1

...

Packet 1

header

context

event 0

event 1

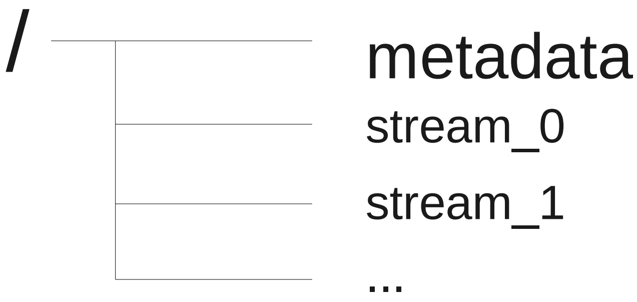
...

...

...

> CTF Diagram: Trace Structure

Trace directory hierarchy:



/

metadata

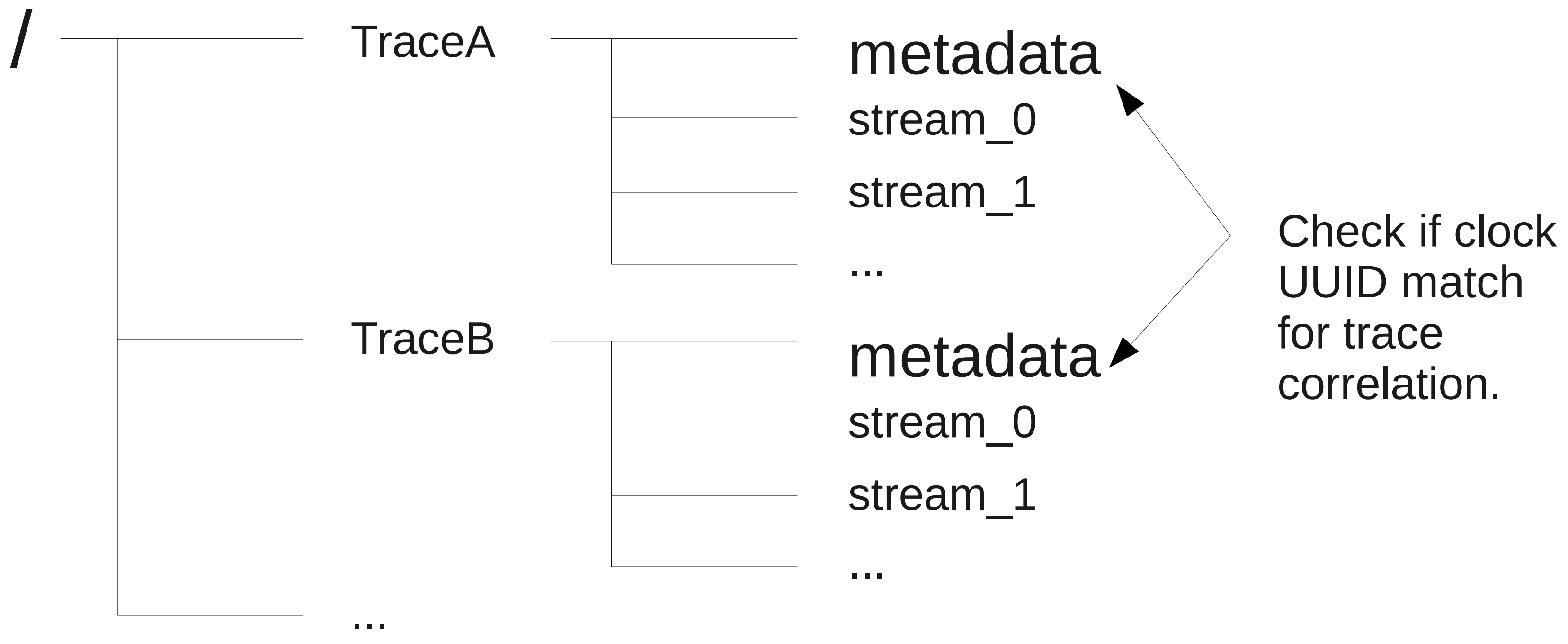
stream_0

stream_1

...

> CTF Diagram: Trace Collection

Trace collection directory hierarchy:



/

TraceA

metadata

stream_0

stream_1

...

TraceB

metadata

stream_0

stream_1

...

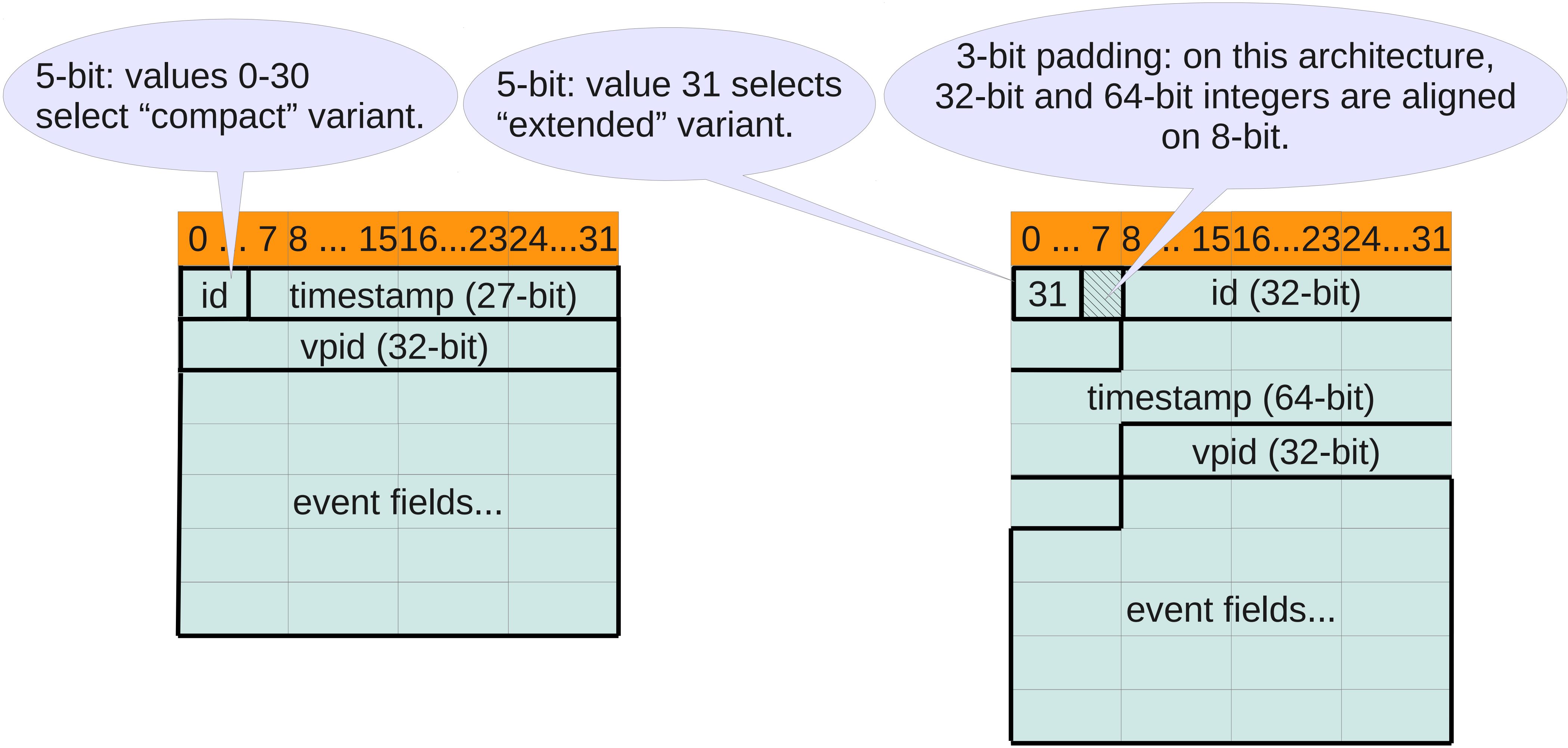
...

Check if clock UUID match for trace correlation.

> Advanced Usage: Variant Type

```
struct event_header_compact {
        enum : uint5_t { compact = 0 ... 30, extended = 31 } id;
        variant <id> {
                struct {
                        uint27_clock_monotonic_t timestamp;
                } compact;
                struct {
                        uint32_t id;
                        uint64_clock_monotonic_t timestamp;
                } extended;
        } v;
} align(8);
```

> Advanced Usage: Variant Type (2)



5-bit: values 0-30 select “compact” variant.
5-bit: value 31 selects “extended” variant.
3-bit padding: on this architecture, 32-bit and 64-bit integers are aligned on 8-bit.
0 ... 7 8 ... 1516...2324...31
id
timestamp (27-bit)
vpid (32-bit)
event fields...
0 ... 7 8 ... 1516...2324...31
31
id (32-bit)
timestamp (64-bit)
vpid (32-bit)
event fields...

> Environment Description

```
env {
        hostname = "thinkos";
        domain = "kernel";
        sysname = "Linux";
        kernel_release = "3.4-trunk-amd64";
        kernel_version = "#1 SMP Tue Jun 26 17:23:03 UTC 2012";
        tracer_name = "lttng-modules";
        tracer_major = 2;
        tracer_minor = 0;
        tracer_patchlevel = 1;
};
```

> Collaboration

- Trace format specification
  - Funded by
    - Linux Foundation CE Linux Forum and Ericsson
  - In collaboration with Multi-Core Association Tool Infrastructure Workgroup
    - Freescale, Mentor Graphics, IBM, IMEC, National Instruments, Nokia Siemens Networks, Samsung, Texas Instruments, Tilera, Wind River, University of Houston, Polytechnique Montréal, University of Utah.
  - Gathered feedback from Linux kernel developers and SystemTAP communities.

> Reference Implementations

- Babeltrace
  - Reference implementation trace conversion tool and read/seek API for trace collections.
  - Initially converts
    - From CTF to text
    - From dmesg text log to CTF
- LTTng kernel 2.0 and LTTng-UST 2.0
  - Native CTF producer reference implementation.
- Eclipse Tracing and Monitoring Framework

> Other tools based on CTF

- GDB (coming in Q4 2012)
- Javeltrace (CTF generator)
- Proprietary converters (derived from Babeltrace)
- LTTngTop
- LTTV
- LTTng Studio

> Areas to Improve

- Support for clocks with varying frequency,
- Mandate some of the currently “suggested” fields,
- Extend CTF to include state change description along with events,
- Extend CTF to include categorization of events,
- Should we keep CTF minimalistic (limited to description of binary layout and clocks), or include high-level semantic information ?

> Questions ?

- CTF specification available at:

  http://www.efficios.com/ctf

EfficiOS

- http://www.efficios.com

- LTTng Information
  - http://lttng.org
  - lttng-dev@lists.lttng.org