Perfmon2: status update

Stéphane Eranian <eranian@google.com>

Agenda

- What changed since last year?
- Status
- Mainline merge challenges

what changed?

perfmon2 interface changes

- No new features, quite the contrary!
- No struct arg modified by programming syscalls
  - used to be for pfarg_setdesc_t (timeout), pfarg_pm*_t (error)
  - possible to share parameters between sessions: system-wide
- Set switch timeout must be multiple of clock granularity
  - kernel does not round it up anymore
  - avoid mistakes later on
  - granularity via clock_getres() (I know, it's not in libc!)

perfmon2 implementation changes

- Use hrtimers for timeout-based event set switching
  - avoid problems with tickless kernel in system-wide mode
  - less overhead
- More modular code
  - group features by module: rw, intr, sets, pmu, init, sysfs, debugfs, syscalls, smpl,...
  - clear separation between kernel and user headers
  - make headers_install
- Rewritten x86 support
  - all PMUs-specific code embedded into PMU description module (code+data)
- Vastly updated sysfs code
- New optional debugfs interface to report perfmon2 statistics

other perfmon2 changes

- Kernel source code managed with GIT on kernel.org
  - improves manageability, visibility
  - improves tracking of code contributions
  - easier to track mainline kernel
- One release for each new mainline kernel
  - yes, libpfm, pfmon version numbers are increasing again!
- All user code + mailing list hosted on SourceForge.net

perfmon2 experimental code

- Utrace-ready (internal tracing engine)
  - automatic support for Roland McGraph's utrace interface
  - key advantage: no ptrace() to stop/resume thread, can invoke syscalls directly
  - need utrace-enabled kernel
- Intel PEBS/BTS/DS management interface (Markus Metzger, Intel)
  - coordinate access to resources via internal API
  - provides DS_AREA, IA32_DEBUGCTL context switch support
  - simplify PEBS code for perfmon2
  - code not yet released, waiting for full ds.h interface in mainline

libpfm changes

- IBM Power4, Power5, Power6 support (IBM)
- IBM Cell support (Toshiba)
- Sicortex Nodechip support (Phil Mucci)
- AMD Barcelona support (AMD)
  - including full support for Instruction Based Sampling (IBS)
- Sun Sparc support (Ultra*, Niagara*) (Dave Miller)
- documentation cleanups (Cray)
- Python bindings (Google)
- dynamic system call numbers detection (2.6.24 and up)

pfmon changes

•Old Pentium II, III, Pro support (Vince Weaver, Cornell U.)

•SUN Sparc support (Ultra*, Niagara*) (Dave Miller)

•IBM Power4, Power5, Power6 support (IBM)

•IBM Cell support (Sony)

•Symbol correlations across dlopen/dlclose (CERN)

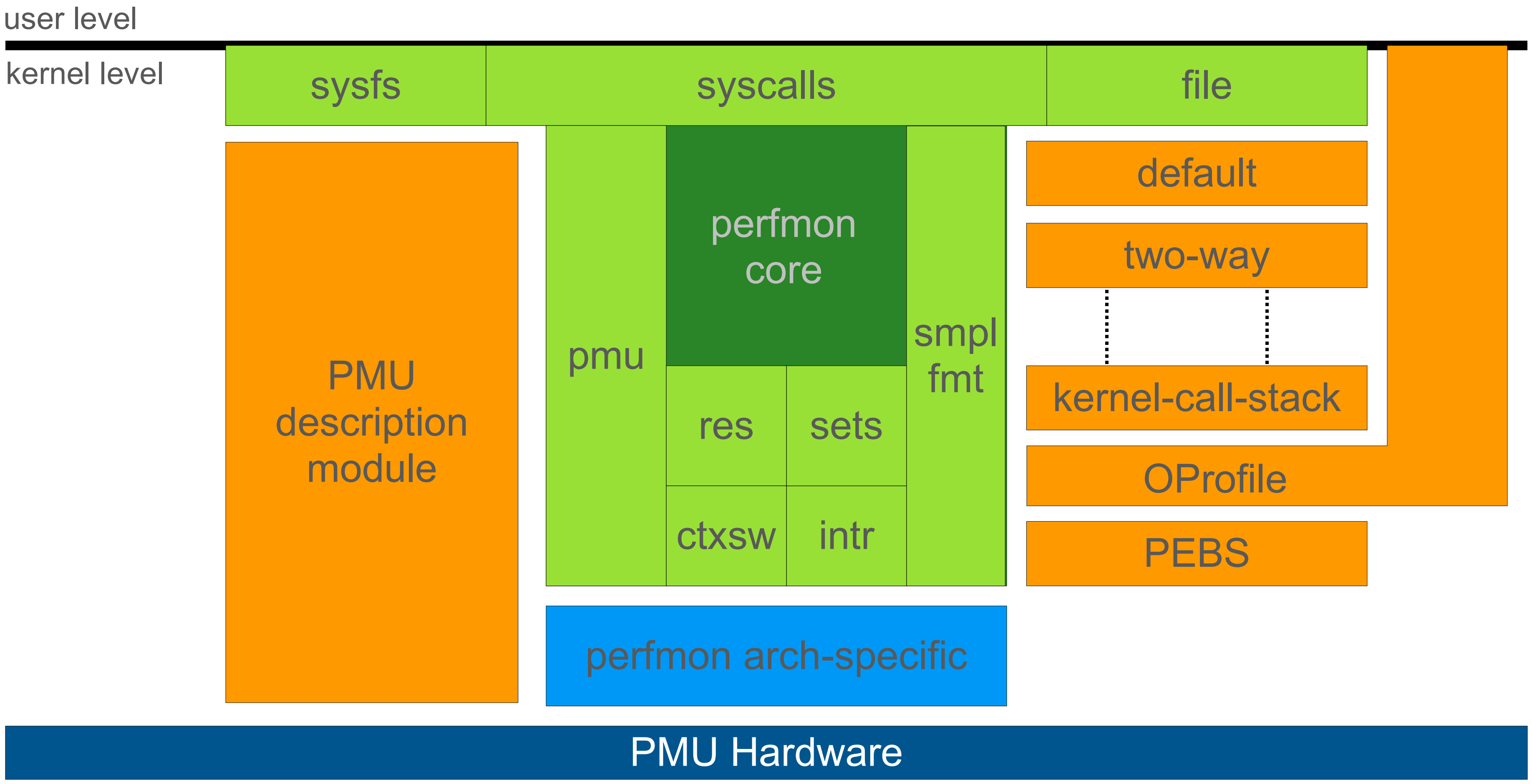
•Process attribution in system-wide (Phil Mucci)

•Intel PEBS support on Core 2

•Lots of bug fixes

status

Perfmon2 architecture summary



Supported processors

HW Vendors	Model	Contributors
AMD	AMD64 family 6	Cornell U.
AMD	AMD64 family 15	Hewlett-Packard Laboratories
AMD	AMD64 family 16	AMD
Intel	Itanium (all models)	Hewlett-Packard Laboratories
Intel	Pentium II, Pentium Pro	Cornell U.
Intel	Pentium III, Pentium M	Hewlett-Packard Laboratories
Intel	Core Duo/Core Solo	Hewlett-Packard Laboratories
Intel	Pentium 4 (Neburst)	Intel
Intel	Core 2 Duo	Hewlett-Packard Laboratories
MIPS	many	Phil Mucci, SiCortex, Broadcom, Cornell U.
IBM	Power4, Power5, PPC970	IBM
IBM	Power 6	IBM
IBM	Cell	IBM, Sony, Toshiba
Cray	X2, XT	Cray
Sun	Ultra12,Ultra3*, Ultra4+	David S. Miller
Sun	Niagara1, Niagara2	David S. Miller

•to come: Intel Nehalem, Intel Tukwila
•still missing: ARM

general status and future work

•up to perfmon v2.8

•soon to be released

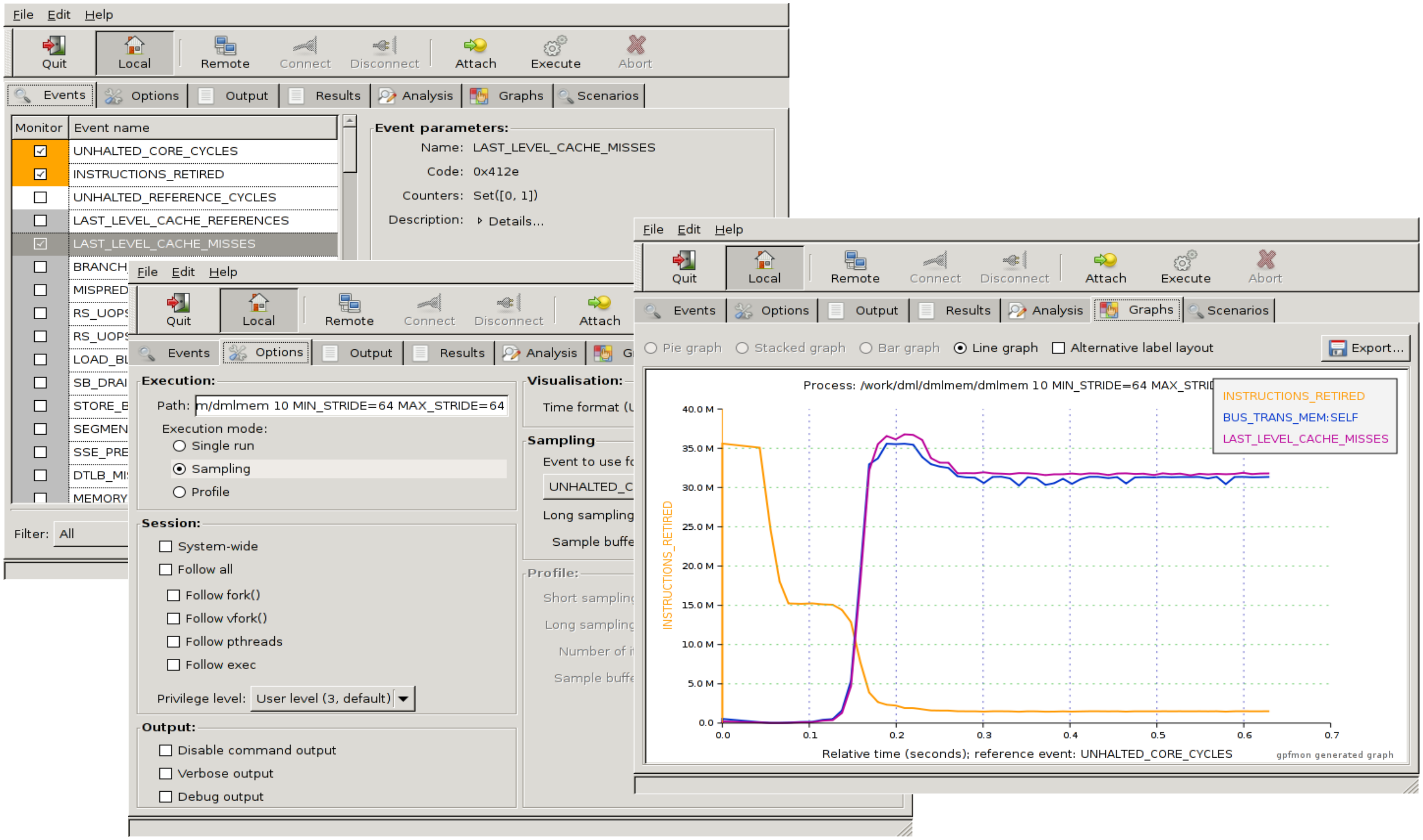
- Linux v2.6.26 patch, libpfm-3.5, pfmon-3.5

•future work:

- focus on merge (cleanup, simplify, explain)
- variable width counters
- drop MASKED state
- add PMD -> PMC dependency information for all PMUs

Gpfmon: pfmon GUI front-end

- Python-based, open-source front-end from CERN


File Edit Help
Quit Local Remote Connect Disconnect Attach Execute Abort
Events Options Output Results Analysis Graphs Scenarios

Monitor	Event name
✓	UNHALTED_CORE_CYCLES
✓	INSTRUCTIONS_RETIRED
☐	UNHALTED_REFERENCE_CYCLES
☐	LAST_LEVEL_CACHE_REFERENCES
✓	LAST_LEVEL_CACHE_MISSES
☐	BRANCH
☐	MISPRED
☐	RS_UOPS
☐	RS_UOPS
☐	LOAD_BL
☐	SB_DRAI
☐	STORE_E
☐	SEGMEN
☐	SSE_PRE
☐	DTLB_MI
☐	MEMORY

Filter: All

Event parameters:
Name: LAST_LEVEL_CACHE_MISSES
Code: 0x412e
Counters: Set([0, 1])
Description: Details...

Execution:
Path: m/dmlmem 10 MIN_STRIDE=64 MAX_STRIDE=64
Execution mode:
( ) Single run
[✓ Sampling]
( ) Profile

Session:
☐ System-wide
☐ Follow all
☐ Follow fork()
☐ Follow vfork()
☐ Follow pthreads
☐ Follow exec
Privilege level: User level (3, default)

Output:
☐ Disable command output
☐ Verbose output
☐ Debug output

Visualisation:
Time format (U

Sampling
Event to use f
UNHALTED_C
Long sampling
Sample buffe

Profile:
Short samplin
Long samplin
Number of
Sample buff

( ) Pie graph ( ) Stacked graph ( ) Bar graph [✓ Line graph] ☐ Alternative label layout Export...

what's up with the merge?

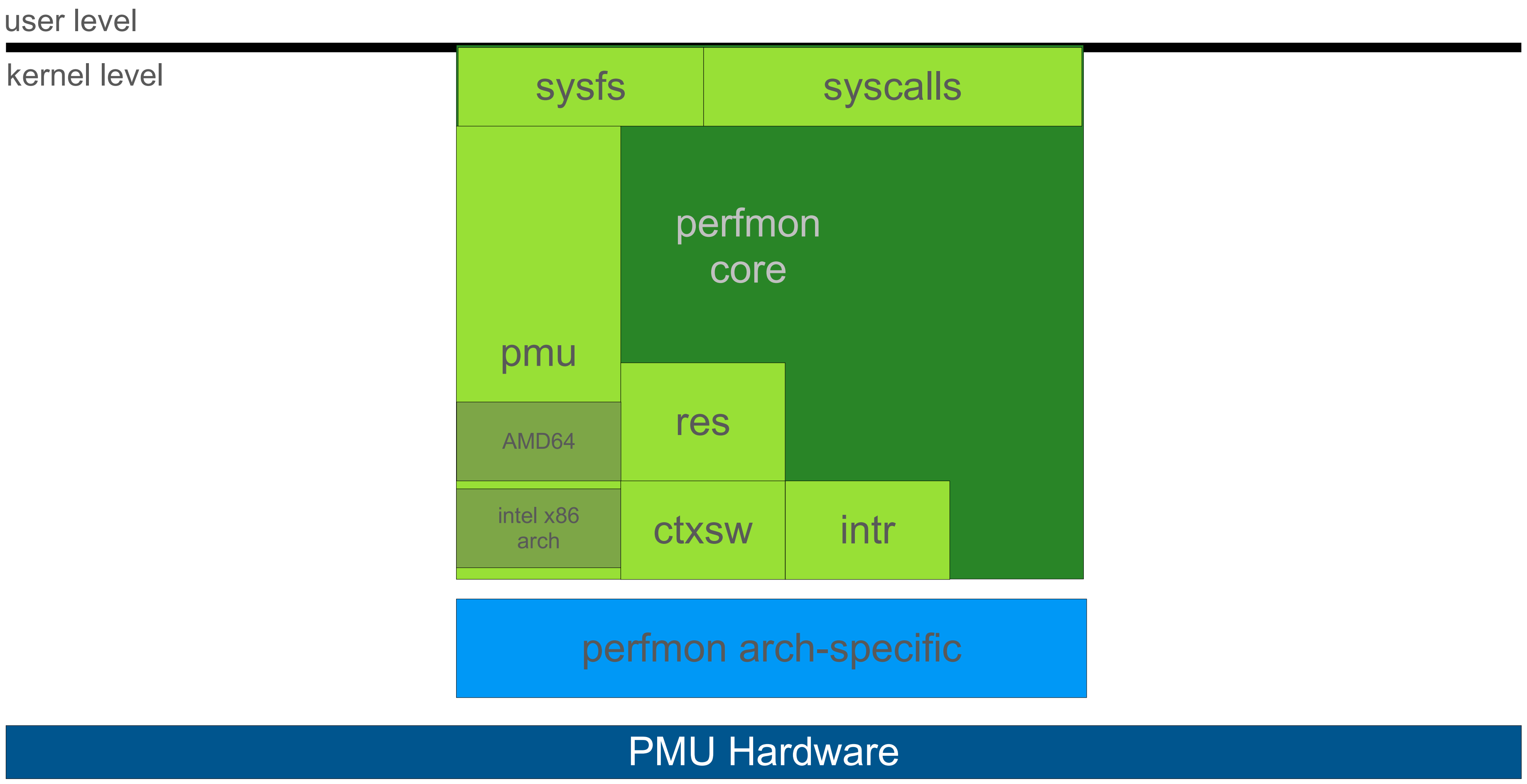
introduction

- To have impact, perfmon2 must be in mainline
  - available in off-the-shelf distros
- Perfmon2 code base is big:
  - spans 5 processor architectures
  - touches context switch, syscalls, fork, exit, kernel exit, interrupt
  - 1.1MB patch, 10,000 lines of C (patch)
- LKML review: cannot be merged as is
  - too big, over-engineered
  - concerns about extensibility (syscalls never disappear)
  - feedback can be constructive: debugfs, sysfs, Kbuild,
- Must start from scratch: perfmon3

Our solution: minimal perfmon

- Start from scratch: perfmon3
  - concentrate first on basic value-add: per-thread counting
  - don't be afraid to break backward compatibility with perfmon2
  - use their tool: quilt
- Quilt: what's that?
  - collection of scripts to manage patches as a stack: push, pop
  - force features (code) to be attributed to a specific patch
  - easy to mail patch stack to LKML
- Minimal perfmon2 quilt series:
  - track linux-next and mainline GIT trees
  - import ONLY code to support per-thread counting
  - drop everything else: sampling, event-sets, PMU descriptions, sampling formats
  - only supports: Intel architectural, AMD AMD64 PMUs
  - 200KB, 2000 lines of C (patch)

Minimal perfmon2 architecture summary



system calls and extensibility

- How to extend a syscall-based interface?
    1. add new system calls
    2. make the syscall parameters extensible

- Parameter extensibility:
    - add new flag for new parameter, then kernel checks:
    - pfm_func(int fd, int flags, pfarg_p_t *p);
    - pfm_func(int fd, int flags, pfarg_p_t *p, pfarg_q_t *q);
    - pfm_func(fd, XTRA_FEATURE, &p, &q)
- Struct extensibility:
    - add new flags for each new feature, reserved no need to be zero
    - struct pfarg_p_t { int flags; uint64_t reserved[8]; }
    - struct pfarg_p_t { int flags; uint64_t new; uint64_t reserved[7]; }
    - struct pfarg_p_t p = { NEW_P, 0xf0, };

syscall interface proposal

int pfm_create_context(pfarg_ctx_t *c, char *s, void *a, size_t s)	int pfm_stop(int fd)
int pfm_write_pmcs(int fd, pfarg_pmc_t *pmcs, int n)	int pfm_restart(int fd)
int pfm_write_pmds(int fd, pfarg_pmd_t *pmcs, int n)	int pfm_create_evtsets(int fd, pfarg_setdesc_t *s, int n)
int pfm_read_pmds(int fd, pfarg_pmd_t *pmcs, int n)	int pfm_delete_evtsets(int fd, pfarg_setdesc_t *s, int n)
int pfm_load_context(int fd, pfarg_load_t *ld)	int pfm_getinfo_evtsets(int fd, pfarg_setinfo_t *i, int n)
int pfm_start(int fd, pfarg_start_t *st)	int pfm_unload_context(int fd);

- Use flags for extensibility
- Merge pfm_start() and pfm_restart()
- Do we need pfm_delete_evtsets()?
- Drop pmd/pmc distinction? pfm_read_reg(), pfm_write_reg()

int pfm_create_context(int flags, char *s, void *a, size_t s)	int pfm_stop(int fd, int flags)
int pfm_write_pmcs(int fd, pfarg_pmc_t *pmcs, size_t s)	
int pfm_write_pmds(int fd, pfarg_pmd_t *pmcs, size_t s)	int pfm_create_evtsets(int fd, int flags, pfarg_setdesc_t *s, size_t s)
int pfm_read_pmds(int fd, pfarg_pmd_t *pmcs, size_t s)	int pfm_delete_evtsets(int fd, pfarg_setdesc_t *s, size_t s) !!!
int pfm_load_context(int fd, int flags, int target)	int pfm_getinfo_evtsets(int fd, pfarg_setinfo_t *i, size_t s)
int pfm_start(int fd, int flags)	int pfm_unload_context(int fd);

summary

•All major processors supported now!

•Feature set is complete

•Merging with minimal patch series

•Strong community of users and contributors, thanks!

Thank You!

Q&A

How we got there?

- incremental work over several years
- most features were requested by advanced users (like you guys!)
  - huge gap between casual and advanced users
- over-engineered to provide maximum flexibility:
  - no need for yet another interface to support new HW
  - successful so far: IBM Power 6, Intel PEBS, AMD IBS, Itanium
- not a big fan of pushing complexity down to kernel
  - no event knowledge
  - system-wide is per-cpu
- development remained outside mainline too long
  - needed to validate interface on all major processors
  - difficult to change APIs once integrated