PariTwine
A bridge between PARI/GP and the GNU MP universe

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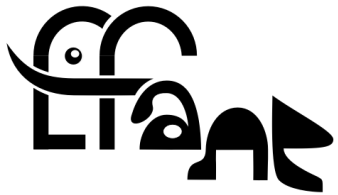

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- Create a bridge between the GNU MP universe and PARI/GP.
- Create a FFI for the GNU MP libraries in PARI/GP.

PARI/GP

- Software for algebra and number theory
- Written since 1985 in Bordeaux
- Number theory backend of SageMath
- C library (PARI) and REPL/command interpreter (GP)

Mini-demo GP

PariTwine

Installation

https://paritwine.multiprecision.org/

- Version 0.0.1 of 2014 — outdated, do not use.
- Development version
  - `git clone https://scm.gforge.inria.fr/anonscm/git/pari-gnump/pari-gnump.git`
  - `autoreconf -vfi`
  - `./configure`
  - `make`
  - `make check`
  - `make install`
  - `make pdf; xpdf doc/paritwine.pdf`

PariTwine

Memory management

- PARI: `t_INT`, `t_FRAC`, `t_REAL`, `t_COMPLEX`
  - stores numbers on the PARI stack
  - allocates sort of automatically:

```
GEN c;
c = gadd (a, b);
```

  - frees by moving the stack pointer (`avma`, `gerepile`)
- GMP, MPFR, MPC: `mpz_t`, `mpq_t`, `mpfr_t`, `mpc_t`
  - store numbers on the heap
  - require explicit allocation (`mpz_init`, `mpc_init2` $\rightarrow$ `malloc`)

```
mpz_t c;
mpz_init (c);
mpz_add (c, a, b);
```

  - require explicit freeing (`mpz_clear`, `mpc_clear` $\rightarrow$ `free`)

```
mpz_clear (c);
```

Precision

- PARI
  - has a global precision for the creation of variables
  - each variable implicitly has a given precision
  - works on a best-effort basis for rounding
- MPFR, MPC
  - assign a separate precision to each variable

    ```
    mpc_init2 (c, 200);
    ```
  - accept a rounding mode per operation and guarantee the result

    ```
    mpc_mul (c, a, b, MPC_RNDND);
    ```

Edianness

- Both store numbers as arrays of `unsigned long int`.
- `t_INT` and `mpz_t` have the same endianness.
- `t_REAL` has the other endianness.

Conversion functions provided by Karim Belabas

Conversion functions: `paritwine.h`

- From PARI to MP*
  - `void mpz_set_GEN (mpz_ptr z, GEN x);`
  - `void mpq_set_GEN (mpq_ptr q, GEN x);`
  - `int mpfr_set_GEN (mpfr_ptr f, GEN x, mpfr_rnd_t rnd);`
  - `int mpc_set_GEN (mpc_ptr c, GEN x, mpc_rnd_t rnd);`

  `x` of type `t_INT`, `t_FRAC`, `t_REAL`, `t_COMPLEX`, as suitable

  Semantics: consider `x` as exact, round and return inexact value

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  `x` of type `t_INT`, `t_FRAC`, `t_REAL`, `t_COMPLEX`, as suitable
  Semantics: consider `x` as exact, round and return inexact value
- From MP* to PARI
  - `GEN mpz_get_GEN (mpz_srcptr z);`
  - `GEN mpq_get_GEN (mpq_srcptr q);`
  - `GEN mpfr_get_GEN (mpfr_srcptr f);`
  - `GEN mpc_get_GEN (mpc_srcptr c);`

  Semantics: Create `t_REAL` or `t_COMPLEX` with the minimal precision to store `f` or `c` without loss

Use the PARI heap for MP*: `paritwine.h`

- Allocate `mpfr` and `mpc` numbers on the PARI heap; do not free!
  - `void pari_mpfr_init2 (mpfr_ptr f, mpfr_prec_t prec);`
  - `void pari_mpc_init2 (mpc_ptr c, mpfr_prec_t prec);`
  - `void pari_mpc_init3 (mpc_ptr c, mpfr_prec_t prec_re, mpfr_prec_t prec_im);`
- Emulate PARI precision handling
  - `void pari_mpfr_init_set_GEN (mpfr_ptr f, GEN x, mpfr_prec_t default_prec);`
  - `void pari_mpc_init_set_GEN (mpc_ptr c, GEN x, mpfr_prec_t default_prec);`

  Allocate on the PARI heap.

  For `t_REAL` components, use their own precision.

  For `t_INT` and `t_FRAC` components, use `default_prec`.

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Functions available in the PARI library

```
#include "paritwine.h"
```

- MPC
  - `GEN pari_mpc_mul (GEN x, GEN y, long prec);`
  - all others!
- MPFR
  - `GEN pari_mpfr_zeta (GEN x, long prec);`
  - all others!
- ARB
  - `GEN pari_acb_zeta (GEN s, long prec);`
  - some more, ask Fredrik!
- CMH
  - `GEN pari_cmh_I2I4I6I10 (GEN tau, long prec);`
  - `GEN pari_cmh_4theta (GEN tau, long prec);`
  - `GEN pari_cmh_10theta2 (GEN tau, long prec);`

pari_mpfr_zeta

```
GEN pari_mpfr_zeta (GEN x, long prec)
{


  mpfr_prec_t p = prec;
  mpfr_t z, z1;

  pari_mpfr_init2 (z, p);
  pari_mpfr_init_set_GEN (z1, x, p);

  mpfr_zeta (z, z1, MPFR_RNDN);

  return                              mpfr_get_GEN (z)   ;
}
```

pari_mpfr_zeta

```
GEN pari_mpfr_zeta (GEN x, long prec)
{
  pari_sp ltop = avma;

  mpfr_prec_t p = prec;
  mpfr_t z, z1;

  pari_mpfr_init2 (z, p);
  pari_mpfr_init_set_GEN (z1, x, p);

  mpfr_zeta (z, z1, MPFR_RNDN);

  return gerepileuptoleaf (ltop, mpfr_get_GEN (z) );
}
```

pari_mpfr_zeta

```
GEN pari_mpfr_zeta (GEN x, long prec)
{
  pari_sp ltop = avma;

  mpfr_prec_t p = prec;
  mpfr_t z, z1;

  pari_mpfr_init2 (z, p);
  pari_mpfr_init_set_GEN (z1, x, p);

  mpfr_zeta (z, z1, MPFR_RNDN);

  return gerepileuptoleaf (ltop, mpfr_get_GEN (z) );
}
```

In reality: macro generated

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Technical perspective

Use the Foreign Function Interface of GP.

```
LIBPARITWINESO="PREFIX/lib/libparitwine.so";
install ("pari_mpfr_zeta", "Gb", "mpfr_zeta", LIBPARITWINESO);
```

- Takes our new function `pari_mpfr_zeta`
- from the installed `libparitwine.so`,
- with one argument of type `GEN` and the default bit precision;
- and calls it `mpfr_zeta` inside GP.

User perspective

```
read ("PREFIX/share/paritwine/paritwine.gp");
mpfr_zeta (3)
```

Mini-demo GP

Plans for the future

- Finish wrapping ARB.
- Wrap CM for use in ECPP.
- Wrap FPLLL to test our LLL implementation (requires vectors and matrices).
- Wrap your favourite library.