

The CADO-NFS software

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Plan

General presentation of CADO-NFS

Features and algorithms

Concluding remarks

Identity card of CADO-NFS

Name: CADO-NFS – (Crible Algébrique: Distribution, Optimisation)

Date of birth: Around 2007

Authors: Many!

Webpage: <http://cado-nfs.gforge.inria.fr/>

Purpose: Integer factorization and discrete logarithm using the number field sieve.

Language: C / C++.

Build/test manager: CMake / CTest

License: GNU LGPL 2.1 or later.

Latest release: 2.1.1 (October 2014).

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If you have a laptop, you are encouraged to download CADO-NFS and play with it during my talk!

(Slowly) learning software engineering. . .

Most of the developers had no training in software engineering.

We have made **progress**:

- Version control system (git);
- Continuous integration;
- Bug tracker;
- Mailing lists (discuss, commit-logs);
- Coverage reports;
- Official releases from time to time;
- Documentation, READMEs.

Still **missing**:

- Global coding style;
- Code review;
- Better packaging in distributions.

Some statistics

Number of **lines of code**:

- 300 k, including 80 k that are macro-generated.
- “active lines” covered by tests: 100 k.
- 20 k lines of python scripts.

Number of **commits**:

- 10,600 commits since 2007.
- around 2000 in the past year.

Main authors (in number of commits):

Paul Zimmermann	2601
Alex Kruppa	2587
Emmanuel Thomé	2112
Pierrick Gaudry	1030
Cyril Bouvier	727
François Morain	426

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Polynomial selection

Feature/algorithm	DL	IF	Comment	Status
Kleinjung's algorithm	X	X	2008 and 2015 improv.	Prod
Conj method for \mathbb{F}_{p^2}	X		for $p \equiv 7 \pmod{8}$	Prod
JL, GJL, JLSV	X		for \mathbb{F}_{p^k}	Todo
Two quadratics		X		Impl
MNFS	X	X		Todo
SNFS	X	X		Todo

Rem. It is possible to import a hand-crafted polynomial pair; with or without rational side.

Factor base construction

Feature/algorithm	DL	IF	Comment	Status
Data for sieving primes and powers	X	X		Prod
Data for exact ideal factorization	X		uses Magma	Prod

Rem. For primes not dividing discriminant nor leading coefficient, very easy.

Rem. For DL, basically need Round 2 at “bad” primes. Currently with Magma, but without using advanced machinery. Translation to C/C++/Python should not be difficult (basic linear algebra).

Relation collection

Feature/algorithm	DL	IF	Comment	Status
F-K sieving algorithm	X	X	only 2 sides	Prod
Cofac using ECM	X	X	fixed sequence	Prod
Multi-threaded	X	X	for saving RAM	Prod
Cofac strategies	X	X		Impl
Batch smoothness cofac	X	X		At work
Scaling to large sizes	X	X	say, more than 768	At work
Sieving in $\dim > 2$	X		Grémy's PhD	At work
Adjust l to q	X	X		Todo
Separation sieve / cofac	X	X		Todo
MNFS	X	?		Todo
(obsolete) Sieving for FFS	X		char 2 and 3	Impl

Filtering

Feature/algorithm	DL	IF	Comment	Status
Duplicate removal	X	X	2-step, on disks on-the-fly	Prod Impl
Singleton and clique	X	X	incl. Bouvier	Prod
Merge	X	X		Prod
Dble matrix trick	?	X	Kleinjung's idea	Todo
Parallel versions	X	X	already multi-thread	Todo

Linear algebra

Feature/algorithm	DL	IF	Comment	Status
Block-Wiedemann	X	X	very flexible	Prod
Node and thread parallelism	X	X	distribute matrix	Prod
Cluster-level parallelism	X	X	with several seq.	Impl
SM incl. as input vectors	X			Prod
Berlekamp-Massey step	X	X	Fast, parallel operational	Prod Prod
Dble matrix trick	?	X		Todo
Lanczos		X		Todo
RNS/AVX/GPU arith.	X		fast!	Impl
Use Galois action	X		for \mathbb{F}_{p^k}	Todo

Characters / SM / Sqrt

Feature/algorithm	DL	IF	Comment	Status
Characters		X		Prod
Schirokauer maps	X			Prod
Sqrt		X	naive	Prod
		X	CRT-based, parallel	Impl

Individual logarithm

Feature/algorithm	DL	IF	Comment	Status
Descent over \mathbb{F}_p	X		missing param files	Prod
Automatic parameters	X			Todo
Init and descent over \mathbb{F}_{p^k}	X			Todo

Rem. For the descent init over \mathbb{F}_p , we use continued fractions and sieving (same binary as for relation collection).

Helper scripts

Feature/algorithm	DL	IF	Comment	Status
Single command-line run	X	X	DL only for \mathbb{F}_p	Prod
Client-server setting	X	X		Prod
Automatic sieving parameters		X	OPAL-based	Impl
HPC scheduler integration	X	X	we have only OAR	Todo
DL in \mathbb{F}_{p^k}	X			At work

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Comparison with QS

Ben Buhrow did some comparisons, using latest release (Oct. 2014).

Some more recent comparison with git version of January 2015:

- CADO-NFS much faster than Magma and Gp/pari for 80dd.
 - Crossover point between Cado-nfs and Msieve-qs is around 85dd.
 - Crossover point between Cado-nfs and Yafu-qs is around 95dd.
- (tests done with just one thread)

Success stories

Computations by CADO-NFS developers:

- 180 digit DL in \mathbb{F}_p . June 2014. Bouvier, Gaudry, Imbert, Jeljeli and Thomé.
- 180 digit DL in \mathbb{F}_{p^2} . June 2014. Barbulescu, Gaudry, Guillevic, Morain
- 120 digit DL in \mathbb{F}_{p^4} . One week ago! Barbulescu, Gaudry, Guillevic, Morain.
- DL in $\mathbb{F}_{2^{809}}$ (with FFS). April 2013. Barbulescu, Bouvier, Detrey, Gaudry, Jeljeli, Thomé, Videau, Paul Zimmermann.
- Many integer factorizations in the 150–190 digits range (aliquot sequences). Zimmermann.
- More to come!

Success stories – 2

Used for **security analysis**:

- Breaking a ransomware using 128 dd RSA keys. Feb 2014. Perigaud, Pernet.
- Breaking Google email DKIM 512-bit RSA key. Oct 2012. Harris.
- PoC for the FREAK attack (Bhargavan et al.). Heninger used Amazon EC2 to factor 512 RSA keys in about 7 hours for 70 USD.
- PoC for the LogJam attack.

Conclusion

CADO-NFS is not the fastest NFS implementation, but:

- Reasonably well packaged, easy to use, even in a parallel context.
- Effort made on portability in Unix world (including MacOS).
- Only “push a button” free implementation of NFS for DL over \mathbb{F}_p .

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We welcome new contributors!