An Analysis of the Security and Privacy Issues of the Neovote Online Voting System

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French elections

French presidential elections in 2022 :

- 2-round paper election, no absentee but proxy voting
- 250M€ for campaigns and organisation
- 48.7 million voters, 5 major parties with primaries

Few regulations for primaries but 4 main rules for e-voting:

- Ensure privacy
- A posteriori verification of tallying
- Ensure transparency of ballot box
- Follow ANSSI rules

Previous and parallel work

Little analysis despite Neovote being one of the biggest French actors: 10k votes per year, competitive public markets and three primaries (EELV, LR, PP).

Criticism of the Primaire Populaire in general :

- Multiple registrations (also for LR primary)
- Tallying method (majority judgement)

Only one public analysis of Neovote, by *de Barros, Gergouil, Grelard and Thibault* :

- Internal elections in Bordeaux University
- Issues with ESMTPS, weak registration, low privacy

Whistle-blower for EELV primary election

Methodology

Methodological and ethical questions :

- Critical election, should we do anything that threatens its legitimacy ?
- How to analyse without interfering

Decisions:

- Register as usual voters without trying to influence the process unduly
- Record everything, download and analyse code (available upon request)
- Compare code with previous elections

Warn institutions and Neovote itself

Neovote's claims and transparency

From Neovote's website :

- 10k votes with no technical issues
- Homologated by top institutions (Senate, National Assembly...)
- Deployed on SecNumCloud but uses no cloud
- Non-standard vocabulary (avoiding mix-nets, random ballot boxes, geometric models)
- No external code, including modified Debian and full cryptographic stack
- No transparency "as they handle top-secret information", no idea of the models, algorithms or code used internally

Code comparisons

First problem: hard to download the scripts and refusal to interact with archiving websites

Main issue: obfuscation

- Regenerating the page changes all variable and function names
- There is a naming scheme
- Structure is maintained, strings too
- Scope sometimes prevents obfuscation

We compare structures and strings

AES_encrypt

```
AES_Encrypt_process
(data: Uint8Array):Uint8Array
{if (!is_bytes(data)) throw new
  TypeError("data isn't of expected type");

  let asm = this.asm;
  let heap = this.heap;
  let amode = AES_asm.ENC[this.mode];
  let hpos = AES_asm.HEAP_DATA;
  let pos = this.pos;
  let len = this.len;
  let dpos = 0;
  let dlen = data.length  0;
  let rpos = 0;
  let rlen = (len + dlen) & -16;
  let wlen = 0;

  let result = new Uint8Array(rlen);

      ⋮
```

```
.xTpmDHxL=function
($xTpmppgF)
{if(!xTpmppDL($xTpmppgF)){throw new
TypeError("data isn't of expected type");}

var $xTpmpDmV=this.$xTpmpDmV;
var $xTpmppgm=this.$xTpmppgm;
var $xTpmpDLT=xTpmpDNN.xTpmDHNL[this.$xTpmpDYs];
var $xTpmppgg=xTpmpDNN.xTpmDHxH;
var $xTpmpDYV=this.$xTpmpDYV;
var $xTpmprNV=this.$xTpmprNV;
var $xTpmppHx=0;
var $xTpmppHs=$xTpmppgF.length0;
var $xTpmpDLY=0;
var $xTpmpDLL=($xTpmprNV+$xTpmppHs)&-16;
var $xTpmppHg=0;

var $xTpmpDLD=new Uint8Array($xTpmpDLL);

      ⋮
```

RSAES-PKCS

```
export function getNonZeroRandomValues
(buf: Uint8Array)
{getRandomValues(buf);
  for (let  i = 0;
  i < buf.length;  i++) {
    let byte = buf[i];
    while (!byte) {
      const octet = new Uint8Array(1);
      getRandomValues(octet);
      byte = octet[0];
    }
    buf[i] = byte;}}
```

```
var xTpmpDDx=function
(xTpmpDpH)
{xTpmpDpD(xTpmpDpH);
for(var $xTpmprNs=0;
$xTpmprNs<xTpmpDpH.length;$xTpmprNs++){
var $xTpmpDDW=xTpmpDpH[$xTpmprNs];
while(!$xTpmpDDW){
var $xTpmpDDV=new Uint8Array(1);
xTpmpDpD($xTpmpDDV);
$xTpmpDDW=$xTpmpDDV[0];
}
xTpmpDpH[$xTpmprNs]=$xTpmpDDW;}
```

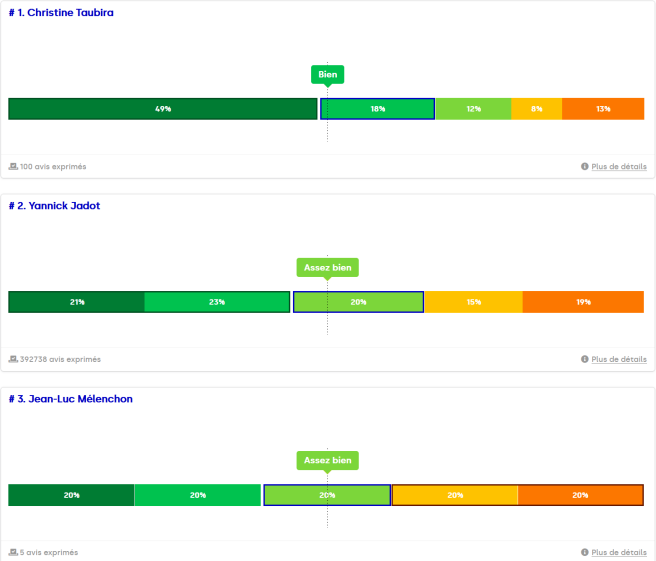
Publishing the tally

From exchanges with PP, their protocol :

- Raw results sent by Neovote to 3 parties : election administration, CNIL expert, and independent legal officer
- Independent confirmation that all went well
- Raw results not made public before control
- Final results computed and published online

Weaknesses because no E2E element and little transparency

Primaire Populaire vote



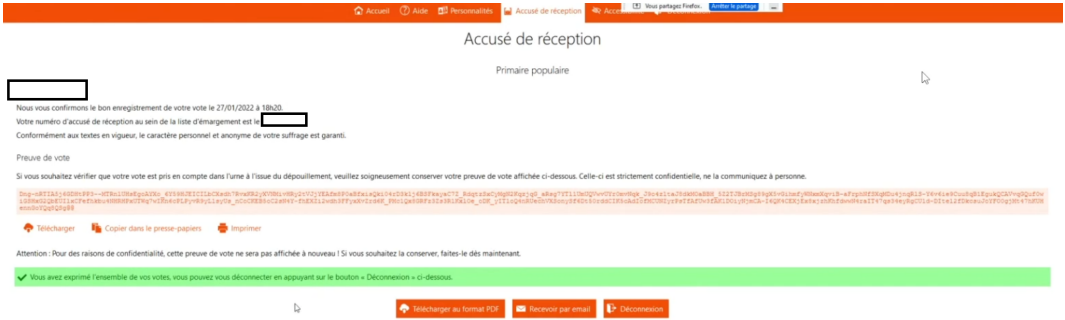
Verification availability and usability

Verification

- "You can check your vote later"
- Proof of vote (long string in browser)
- Forbidden to share proof of vote
- Easy to skip the proof of vote

For EELV it worked. For PP : no information on how to verify.

Verification availability and usability



Checking the verification

No publicly available code this time :

- Analyse EELV code
- Authenticate it by structure and function re-use
- Compatible with other analyses

Verification structure

Structure :

- Each receipt is composed of 5 hashes (computed on the client's side, encrypted using a constant public key)
- Ballot box is list of (ballot, hash)
- Extra (void) hashes in a different file

Verification protocol :

- Remove hashes present in *extra*
- Check that the remaining are in the ballot box
- Ask the server to decrypt all ballots (RSA using its public key)
- Tally the votes

Attacking the ballot box

Ballot box vulnerabilities

- The ballot box is not digitally signed
- We can create a fake ballot box with arbitrary data and make it indistinguishable from the real one

Receipt vulnerabilities

- The receipts are not digitally signed
- We can create fake-receipts attacks and denounce the election

Deanonymising voters

Hard to be sure, but current hash structure indicates that :

- If no extra hash is in ballot box (all in extra hashes) then voter can prove how they voted
- If some hashes only are present, voter can prove how they did not vote

We assume that hashes are generally not included in *extra hashes*.

- If voters don't share receipts, organisers can easily re-use hashes and modify the ballot box.
- If receipts are often made public, we can create sequences of receipts and prove how one voted (or did not vote) or have high probability that they voted a certain way.

Legal decisions

French legal decisions

- Appellate Court : cancelled a vote by Neovote in 2019 as not sufficiently guaranteeing privacy
- Supreme Court : expertise *in abstracto* is enough. Checking the system each time is not necessary
- Recommended privacy requirements are too weak (even with 2-factor, because of public data).

Conclusion

We see a multiplication of commercial e-voting systems.

The legal frameworks do not appear solid enough to impose good security.

How do we shift from technical expertise to mandated regulations, and make sure those are applied ?