

fn sample_geometric_buffer

Vicki Xu, Hanwen Zhang, Zachary Ratliff

December 22, 2025

This document proves soundness of `sample_geometric_buffer` in `mod.rs` at commit `f5bb719` (outdated¹).

1 Hoare Triple

Preconditions

None

Pseudocode

```
1 def sample_geometric_buffer(
2     buffer_len: usize, constant_time: bool
3 ) -> Optional[uint]: #
4     if constant_time:
5         buf = bytearray(buffer_len)
6         fill_bytes(buf) # mutates in-place
7         ret = None
8         for i in range(buffer_len):
9             # find first nonzero event
10            if buf[i] > 0:
11                # compute index of first nonzero bit buffer
12                cand = 8 * i + buf[i].leading_zeroes() #
13                ret = cand if ret is None else min(ret, cand)
14        return ret
15    else:
16        for i in range(buffer_len):
17            buf = bytearray(1)
18            fill_bytes(buf) # mutates in-place
19            if buf[0] > 0:
20                return 8 * i + buf[0].leading_zeroes()
21
22    return None
```

Postcondition

For any setting of the input arguments, `sample_geometric_buffer` either raises an exception if there is insufficient system entropy, or returns `sample` where `sample` is drawn from a discrete distribution.

`sample` is either `geo` where `geo` is a sample from the $Geometric(p = 0.5)$ distribution, and is less than `buffer_len * 8`, or `None` with probability $2^{-\text{buffer_len}*8}$.

Proof. `sample_geometric_buffer` uses `fill_bytes` as a subroutine to generate a buffer of `buffer_len` bytes. For each bit b in the buffer it follows that $\Pr[b = 1] = \frac{1}{2}$ and $\Pr[b = 0] = \frac{1}{2}$. If there is some bit in the buffer equal to 1, the position of the *first* such bit is a zero-indexed draw from the Geometric distribution

¹See new changes with git diff f5bb719..fe1abca rust/src/traits/samplers/geometric/mod.rs

$\text{Geom}(p)$ with $p = 0.5$, by definition of a Geometric random variable. If the buffer is zero, the function returns `None`. \square