

fn sample_geometric_buffer

Vicki Xu, Hanwen Zhang, Zachary Ratliff

July 6, 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_zeros() #  
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_zeros()  
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 $2^{-buffer_len * 8}$.

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..c81ba84 rust/src/traits/samplers/geometric/mod.rs`

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