

# impl TopKMeasure for MaxDivergence

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This proof resides in “`contrib`” because it has not completed the vetting process.

This document proves soundness of `TopKMeasure` for `MaxDivergence` in `mod.rs` at commit `e62b0aa2` (outdated<sup>1</sup>).

## 1 Hoare Triple

### Precondition

#### Compiler-verified

- Associated Const `REPLACEMENT = false`
- Method `privacy_map`  
*Types consistent with pseudocode.*

#### Caller-verified

- Method `privacy_map`
  - `d_in` is non-null and positive.
  - `scale` is non-null and positive.

### Pseudocode

```
1 # MaxDivergence
2 REPLACEMENT = False
3
4 def privacy_map(d_in: f64, scale: f64) -> f64:
5     return d_in.inf_div(scale)
```

### Postcondition

**Theorem 1.1.** The implementation is consistent with the associated items in the `TopKMeasure` trait.

- Method `privacy_map`: For any  $x, x'$  where  $d_{in} \geq d_{Range}(x, x')$ , return  $d_{out} \geq D_{self}(f(x), f(x'))$ , where  $f(x) = \text{noisy\_top\_k}(x = x, k = 1, \text{scale} = \text{scale}, \text{replacement} = \text{Self} :: \text{REPLACEMENT})$ .

*Proof.* Since `Self::REPLACEMENT` is false, then by the postcondition of `noisy_top_k`, `noisy_top_k` returns a sample from  $\mathcal{M}_{PF}$ . In the case that scores are not monotonic, by [1] Theorem 1,  $\mathcal{M}_{PF}$  satisfies  $\epsilon$ -DP, because the range distance is equal to  $2 \cdot \Delta$ . Otherwise in the case that scores are monotonic, by [1] Remark 1,  $\mathcal{M}_{PF}$  satisfies  $\epsilon/2$ -DP, but the range distance is equal to  $\Delta$ , thus satisfying  $\epsilon$ -DP.  $\square$

<sup>1</sup>See new changes with `git diff e62b0aa2..9bdaf70 rust/src/measurement/noisy_top_k/mod.rs`

## References

- [1] Ryan McKenna and Daniel Sheldon. Permute-and-flip: A new mechanism for differentially private selection, 2020.