Supplementary Material

This document contains supplementary material to the paper *Total Recall? How Good are Static Call Graphs Really?*

1 PROOFS

This section gives proofs for the theorems included in the paper.

1.1 Theorem 3.3 (Bounds on Precision)

First, remember that

$$\text{Precision}_{SD} = \frac{|S \cap D|}{|S|}$$

and

$$\text{Precision}_{SG} = \frac{|S \cap G|}{|S|}$$

Since $D \subseteq G$ it follows that $|S \cap D| \leq |S \cap G|$ and thus

$$\text{Precision}_{SD} = \frac{|S \cap D|}{|S|} \leq \frac{|S \cap G|}{|S|} = \text{Precision}_{SG}$$

$\square$

1.2 Theorem 3.4 (Bounds on Recall)

Remember that

$$\text{Recall}_{SD} = \frac{|S \cap D|}{|D|}$$

,

$$\text{Recall}_{DG} = \frac{|D \cap G|}{|G|}$$

and

$$\text{Recall}_{SG} = \frac{|S \cap G|}{|G|}$$

We prove each bound separately.

1.2.1 Lower Bound.

$$\text{Recall}_{SD} * \text{Recall}_{DG} = \frac{|S \cap D|}{|D|} * \frac{|D \cap G|}{|G|} = \frac{|S \cap D|}{|G|} * \frac{|D \cap G|}{|D|}$$

Since $D \subseteq G$ it follows that $D \cap G = D$ and thus

$$\frac{|S \cap D|}{|G|} * \frac{|D \cap G|}{|D|} = \frac{|S \cap D|}{|G|} * \frac{|D|}{|D|} = \frac{|S \cap D|}{|G|}$$

Since, again, $D \subseteq G$ it follows that $|S \cap D| \leq |S \cap G|$ and thus

$$\text{Recall}_{SD} * \text{Recall}_{DG} = \frac{|S \cap D|}{|G|} \leq \frac{|S \cap G|}{|G|} = \text{Recall}_{SG}$$

$\square$

1.2.2 Upper Bound.

We first introduce the *false-negative rate*:

$$FNR_{XY} = \frac{|Y \smallsetminus X|}{|Y|}$$

$Y = (Y \cap X) \uplus (Y \smallsetminus X)$ yields $|(Y \cap X)| + |(Y \smallsetminus X)| = |Y|$, so

$$FNR_{XY} = \frac{|Y \smallsetminus X|}{|Y|} = \frac{|Y| - |Y \cap X|}{|Y|} = 1 - \frac{|Y \cap X|}{|Y|} = 1 - \text{Recall}_{XY}$$

Now consider $FNR_{SD} * \text{Recall}_{DG}$:

$$FNR_{SD} * \text{Recall}_{DG} = \frac{|D \smallsetminus S|}{|D|} * \frac{|D \cap G|}{|G|} = \frac{|D \smallsetminus S|}{|G|} * \frac{|D \cap G|}{|D|}$$

Since $D \subseteq G$ it follows that $D \cap G = D$ and thus

$$\frac{|D \smallsetminus S|}{|G|} * \frac{|D \cap G|}{|D|} = \frac{|D \smallsetminus S|}{|G|} * \frac{|D|}{|D|} = \frac{|D \smallsetminus S|}{|G|}$$

Since, again, $D \subseteq G$ it follows that $|D \smallsetminus S| \leq |G \cap S|$ and thus

$$FNR_{SD} * \text{Recall}_{DG} = \frac{|D \smallsetminus S|}{|G|} \leq \frac{|G \smallsetminus S|}{|G|} = FNR_{SG}$$

We replace FNR_{XY} by $1 - \text{Recall}_{XY}$ twice:

$$(1 - \text{Recall}_{SD}) * \text{Recall}_{DG} \leq 1 - \text{Recall}_{SG}$$

Subtract 1 from both sides:

$$(1 - \text{Recall}_{SD}) * \text{Recall}_{DG} - 1 \leq -\text{Recall}_{SG}$$

Multiply bots sides by -1 and rearrange:

$$1 - (1 - \text{Recall}_{SD}) * \text{Recall}_{DG} \geq \text{Recall}_{SG}$$

$\square$

1.2.3 Distance of Bounds.

We shortly prove the distance of the bounds to be $1 - \text{Recall}_{DG}$:

$$1 - (1 - \text{Recall}_{SD}) * \text{Recall}_{DG} - \text{Recall}_{SD} * \text{Recall}_{DG} =$$
$$1 - (\text{Recall}_{DG} - \text{Recall}_{SD} * \text{Recall}_{DG}) - \text{Recall}_{SD} * \text{Recall}_{DG} =$$
$$1 - \text{Recall}_{DG} + \text{Recall}_{SD} * \text{Recall}_{DG} - \text{Recall}_{SD} * \text{Recall}_{DG} =$$
$$1 - \text{Recall}_{DG}$$

$\square$

2 PROGRAMS, SCRIPTS, AND RAW DATA

The zip package contains our evaluation pipeline used for our empirical studies. `Justfiles`[1] files define recipes to build our test harnesses, start the fuzzing process, create dynamic and static CGs and compare them. Due to their size, we excluded the input corpora—we will publish them in our artifact upon acceptance.

The zip also contains all scripts to generate the figures in our paper and the raw data figures and tables are based on.

3 PRECISION AND RECALL FIGURES

The figure on the next page presents all precision, recall, and CG size measures in one overview.

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[1] https://github.com/casey/just