CALCULATING BOUNDS ON INFORMATION LEAKAGE USING MODEL-CKECINGG TOOLS

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In Partial Fulfillment
of the Requirements for the Degree
Master of Science

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by

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The undersigned, appointed by the Dean of the Graduate School, have examined the thesis entitled:

CALCULATING BOUNDS ON INFORMATION LEAKAGE USING MODEL-CKECINGG TOOLS

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a candidate for the degree of Master of Science and hereby certify that, in their opinion, it is worthy of acceptance.

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This page is where you would acknowledge all those who helped you with your academic research. This is not necessarily where you would recognize loved ones who supported you during your studies. That would be more appropriately done in an optional Dedication page. I would like to thank Professor Smith Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Vestibulum eu tellus. Nullam et odio eget sapien porttitor interdum. Donec vel ante. Maecenas in sem a nunc viverra hendrerit. Quisque ut massa quis pede blandit pharetra.

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ABSTRACT

This is the abstract of your dissertation project. It should not exceed one page.

Chapter 1

Introduction

Introduce the reader to the current problem that you wish to solve, and why anyone should care about it.

Chapter 2

Theory background

2.1 Min-entropy

The introduction counts as chapter 1. This page shows how the bulk of your thesis will be organized: through chapters and sections. Here is a citation.[**?**]

2.2 Information leak

2.3 Two intuitive solutions

To count the number of outputs of a program, we come up with two approaches: Put the program in a double loop and count the number of outputs, or iterate through all input values and record the outputs in a table. The first approach is time-consuming, while the second one is space-consuming.

2.3.1 Double loop and counter

In algorithm 1, for each possible output value, we iterate through the input range to see if an input can result in this output. If we hit such an input, counter increases and the code breaks out of the inner loop to continue testing the next possible output value. After the double loop finishes, the value of $OCounter$ is the number of outputs of program P.

Algorithm 1 Calculate the number of outputs using double loop.

```
S ← 0
O ← 0
SIn ← 0
OOut ← 0
OCounter ← 0
SMax ← 1 << bitLength − 1
OMax ← 1 << bitLength − 1
for O = 0 to OMax do
  for S = 0 to SMax do
    SIn ← S
    OOut ← P(SIn) // the program P takes SIn as input
    if OOut = O then
      OCounter ← OCounter + 1
      break
    end if
  end for
end for
```

In algorithm 1, we declared seven variables, and all of them requires $bitLength$ bits except for $OCounter$ which is $bitLength + 1$ bits. The total memory usage for variables is $7 \times bitLength + 1$ at $O(bitLength)$. As with execution time, we assume program P takes time $t(P)$ to execute, and the total execution time for the double loop when break is never reached is $2^{bitLength} \times 2^{bitLength} \times t(P)$ at $(2^{O(bitLength)})$.

2.3.2 Single loop and table

In algorithm 2, we create a table with size equal to the maximum number of possible outputs($1 << bitLength$), and we use its indices as output values. $OHit[O] = 1$ means O is an output for program P. When a 0 turns to 1, we increase $OCounter$. After the loop, the value of $OCounter$ is the number of outputs by program P.

Algorithm 2 Calculate the number of outputs using single loop and a table.

```
S ← 0
O ← 0
SIn ← 0
OOut ← 0
OCounter ← 0
SMax ← 1 << bitLength − 1
OMax ← 1 << bitLength − 1
OHit[OMax + 1] ← [0]
for S = 0 to SMax do
   SIn ← S
   OOut ← P(SIn) // the program P takes SIn as input
   if OHit[OOut] = 0 then
      OCounter ← OCounter + 1
      OHit[OOut] ← 1
   end if
end for
```

In algorithm 2 except for the array we have 7 variables using $7 \times bitLength + 1$ memory. The array $OHit[]$ is of size $bitLength \times bitLength$ making a total of $bitLength^2 + 7 \times bitLength + 1$ at $O(bitLength^2)$. As with execution time, we assume program P takes time $t(P)$ to execute, and the execution time for the single loop is $2^{bitLength} \times t(P)$ at $(2^{O(bitLength)})$.

Chapter 3

Experiment with Getafix

We want to use model-checking tools to see if we can reduce the time requirement of algorithm 1. Specifically, we choose the reachability property(why and what other property are there) and append algorithm 3 to the end of algorithm 1. The statement within the if statement has a label. Although the exact statement following that label is irrelevant, reaching this line means $OCounter$ satisfies the constrains in the condition block.

We experimented on several model-checking tools, including Interproc from [1], Berkeley Lazy Abstraction Software Verification Tool(Blast) from [2] and Getafix from [3]. We can not get correct reachability results from Interproc and Blast, so we shift our focus on Getafix.

Algorithm 3 Determine if $OCounter$ meets certain constrains.

```
if value of OCounter meets certain constrains then
  reach: OCounter // a label followed by a statement
end if
```

3.1 Getafix

Getafix is a symbolic model checker for Boolean programs implemented in [3]. Getafix only supports reachability check. It translates sequential and concurrent Boolean programs into Boolean formulae and uses the model-checker Mucke to solve the reachability problem symbolically using Boolean Decision Diagrams [4].

3.2 The converter

Input for Getafix are boolean programs, meaning it only supports boolean variables which can be either 0 or 1. We represent our problem in decimal, thus we need to translate it into boolean form. We implemented a converter to automate this process. The converter has three components, a parser, a built-in function generator and a piece of script which calls the first two components and assemble the output file.

Input to the parser is the decimal code file and the desired bit length. Output of the parser is its corresponding binary program which follows the syntax of Getafix input file. First we define the syntax of input code to the parser and second we create the parser using flex and bison. The parser scans the input code and builds a syntax tree. Then the parser prints the syntax tree as a binary program. The parser has three points worth noting:

1. When printing the output code, the parser "stretches" each variable and literal into its binary form. Assume the desired bit length is $bitLength$. We split each variable into $bitLength$ variables by copying the name of the variable $bitLength$

3.3 Tests and results

3.3.1 Sanity check

Chapter 4

Monotonic programs

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Chapter 5

Summary and concluding remarks

Congratulations on completing your dissertation.

Appendix A

Title of first appendix

A.1 Section title

Here is some additional information which would have detracted from the point being made in the main article.

A.1.1 Subsection title

This section even has subtitles

Bibliography

[1] Interproc, 2011.

[2] MTC (models and theory of computation): BLAST project, 2008.

[3] Salvatore La Torre, Madhusudan Parthasarathy, and Gennaro Parlato. Analyzing recursive programs using a fixed-point calculus. In *Proceedings of the 2009 ACM SIGPLAN Conference on Programming Language Design and Implementation*, PLDI '09, page 211222, New York, NY, USA, 2009. ACM.

[4] Getafix – boolean program checker, 2009.

VITA

This is a summary of your *professional* life, and should be written appropriately. This can be written in the following order: where your where born, what undergraduate university you graduated from, if you received a masters, and which institution you graduated from with your PhD (University of Missouri). You can describe when you began research with your current advisor.

In another paragraph, you could say if/when you were married, what the name of your kids are, and what your plans are for after graduation if you choose. Take a look at other vita's from other dissertations for examples.