# Enhancing the Performance of the DynamoRIO Memtrace Client for Memory-Intensive Workloads and Exploring Last-Level Branch Prediction

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thodology Background Improvements Made Results Inferences Future Scope

- 1 Introduction and Aim
- 2 Methodology

Introduction and Aim

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- 3 Background
- 4 Improvements Made
- 6 Results
- 6 Inferences
- **7** Future Scope



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dology Background Improvem

Improvements Made

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#### Introduction

Introduction and Aim

Dynamic binary instrumentation (DBI) tools such as DynamoRIO is essential for analyzing software, providing valuable insights into how programs behave while they're running.





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DynamoRIO and LLBP 3 / 24

#### Aim

Introduction and Aim

- To enhance the performance of the DynamoRIO Memtrace client for memory-intensive workloads.
- To explore the concept of Last-Level Branch Prediction (LLBP) and its potential benefits in improving the Branch Prediction.



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Methodology

- 2 Methodology
- 4 Improvements Made
- 6 Results



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Methodology

## Methodology

- Understanding Current tracing client
- Selecting and understanding the Benchmark
- Look for some optimizations
- Exploring LLBP



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- 3 Background
- 4 Improvements Made
- 6 Results



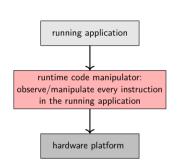
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Background 0000

## DynamoRIO's Architecture

- DynamoRIO: A runtime code manipulation system
- Core features: Efficiency, transparency, and comprehensive control
- Functionality: Intercepting and modifying every executed instruction



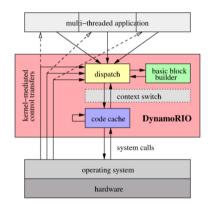


8 / 24

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## DynamoRIO's Architecture

- Core operation: Shifting execution to a specialized code cache
- Dynamic basic block management: Incremental copying of application code
- Trace formation: Amalgamation of frequently executed basic block sequences
- Indirect branch resolution: Techniques like inlined table lookups or comparisons





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Background

# **Understanding Memtrace**

- Working of the code
- Trace format
- Buffering techniques used
- Scope for improvement



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- Introduction and Aim
- 2 Methodology
- Background
- 4 Improvements Made
- 6 Results
- 6 Inference
- 7 Future Scop



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## Improvements Made

- Change to dr\_fprintf
- Using binary format rather than text
- Changing buffer size
- Using offset in the address
- Compressing the output data before writing to file



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Results •0000

- 4 Improvements Made
- 6 Results



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## Change of Bandwidth with Tracing

S. No	Trace En- abled	Trace File Format	Сору	Scale	Add	Triad	Avg Rate	Trace File Size	Write BW	Time	Total
			(MB/s)	(MB/s)	(MB/s)	(MB/s)	(MB/s)	(GB)	(MB/s)	(Sec)	(MB/s)
1	No	-	20007.7	19543.4	23354.9	23444.5	21587.63	_	0	1	21587.63
2	Yes	Text	7.2	3.8	5.6	5.7	5.57	53.4	24.37	2244	29.9
3	Yes	Binary	658.4	425.6	649.9	676.1	602.5	50.3	2452.7	21	3055.22



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3	Yes	Binary	658.4	425.6	649.9	676.1	602.5	50.3	2452.7	21	3055.22

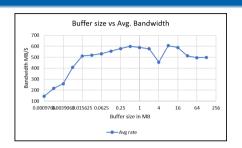
85.85% Performance Loss from No Trace to Binary Trace



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#### **Buffer Performance Table**

Buffer Size	C	C1-	Add	Total	Avg rate	Time
(MB)	Сору	Scale	Add	Triad	(MB/Sec)	(Sec)
0.000976563	160.7	107.8	162.9	158.7	143.8	80
0.001953125	244.1	160.5	243.5	237.8	216.03	54
0.00390625	373.8	230.9	169.4	174.7	258.03	114
0.0078125	454.4	305.6	464.5	461.7	408.17	30
0.015625	566.9	385.2	579.4	582.8	510.5	25
0.03125	590.9	390.1	576.4	642.5	519.13	23
0.0625	586.8	407.7	604.1	690.5	532.03	28
0.125	621.1	429.4	614.2	596.1	554.9	27
0.25	658.4	425.6	649.9	676.1	577.97	21
0.5	654.1	466.9	675.4	655.6	598.8	19
1	642.4	451.5	671	681.5	588.3	21
2	668	420.7	643	647	577.23	32
4	515.2	339.4	508.8	493.2	454.47	29
8	689.7	448.6	676.5	678.7	604.93	28
16	676.7	438.2	652.3	641.2	589.07	28
32	577.4	380.4	578.9	559.1	512.23	26
64	560.7	356.2	562.8	543.4	496.23	30
128	563.3	359.8	569.6	554.4	497.57	25





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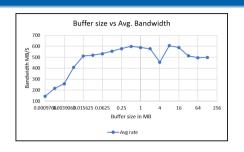
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0.125	621.1	429.4	614.2	596.1	554.9	27
0.25	658.4	425.6	649.9	676.1	577.97	21
0.5	654.1	466.9	675.4	655.6	598.8	19
1	642.4	451.5	671	681.5	588.3	21
2	668	420.7	643	647	577.23	32
4	515.2	339.4	508.8	493.2	454.47	29
8	689.7	448.6	676.5	678.7	604.93	28
16	676.7	438.2	652.3	641.2	589.07	28
32	577.4	380.4	578.9	559.1	512.23	26
64	560.7	356.2	562.8	543.4	496.23	30
128	563.3	359.8	569.6	554.4	497.57	25



#### **New Bandwidth:**

$$604.93 + \left(\frac{50.3 \, \text{GB}}{28 \, \text{sec}}\right) =$$
**2444.47 MB/Sec**

88.67% Performance Loss with new Buffer Size

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 Background 0000
 Improvements Made 000 00
 Results 000 00
 Inferences 000 00
 Future Scope 000 00

## Change of Bandwidth with offset

Trace File Forma		Scale	Add	Triad	Avg Rate	Trace File Size	Write BW	Time	Total
	(MB/s)	(MB/s)	(MB/s)	(MB/s)	(MB/s)	(GB)	(MB/s)	(Sec)	(MB/s)
Binary	727.0	479.9	715.1	714.7	659.18	50.3	2575.36	20	3234.54



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odology Background Improvements Made Results Inferences Future Scope

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## Change of Bandwidth with offset

Trace File Format	Сору	Scale	Add	Triad	Avg Rate	Trace File Size	Write BW	Time	Total
	(MB/s)	(MB/s)	(MB/s)	(MB/s)	(MB/s)	(GB)	(MB/s)	(Sec)	(MB/s)
Binary	727.0	479.9	715.1	714.7	659.18	50.3	2575.36	20	3234.54

85.01% Performance Loss from No Trace to Binary Trace



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## Change of Bandwidth with offset

Trace File Format		Scale	Add	Triad	Avg Rate	Trace File Size	Write BW	Time	Total
	(MB/s)	(MB/s)	(MB/s)	(MB/s)	(MB/s)	(GB)	(MB/s)	(Sec)	(MB/s)
Binary	727.0	479.9	715.1	714.7	659.18	50.3	2575.36	20	3234.54

**5.54%** improvement from default memtrace client



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## Compression the data with LZ4

No. of times Buffer Size	Сору	Scale	Add	Triad	Avg rate (MB/Sec)	Time (Sec)
1	496.9	444.2	494.7	490.3	481.525	24
2	365.5	322.2	371.2	363.7	355.65	34
3	423.3	368.2	417.9	415.8	406.3	29
4	498.5	443.7	494.9	491.4	482.125	24
5	495.2	441.8	494.9	488.7	480.15	24
6	487.8	434.7	484.8	479.9	471.8	25
7	488.0	434.9	485.0	480.1	472	24
8	493.9	439.8	493.3	486.8	478.45	24
9	490.8	430.1	492.0	485.7	474.65	24
10	490.4	436.9	490.0	483.3	475.15	24
11	489.5	434.4	488.7	482.6	473.8	25
12	488.3	435.8	489.6	483.0	474.175	24
13	490.8	435.9	487.6	483.1	474.35	25
14	480.3	424.9	478.0	472.4	463.9	25
15	488.2	431.9	486.2	480.2	471.625	24
16	466.7	411.7	464.6	460.7	450.925	26
32	478.0	421.9	477.4	471.5	462.2	25
64	457.1	398.0	455.9	450.7	440.425	26

#### **New Bandwidth:**

$$481.5 + \left(\frac{7.1 \, GB}{24 \, sec}\right)$$
= 784.43 MB/Sec



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- 6 Results
- 6 Inferences



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- Improvement through offset:
  - 5.54% improvement from defalut memtrace client
- Compression:
  - Compression is becoming overhead and leading to a lower bandwidth in the application
  - But there is significant reduction in the file size 7.1GB from 50.3GB
  - So there is a trade off here



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- 4 Improvements Made
- 6 Results
- **7** Future Scope



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## Future Scope

- Check the current client with other real world benchmarks
- Dynamic Scheduling Strategies



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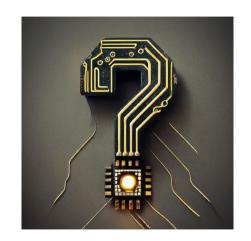














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## Thank You





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## References

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- https://groups.csail.mit.edu/cag/rio/derek-phd-thesis.pdf
- https://github.com/lz4/lz4
- https://www.cs.virginia.edu/stream/



End

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