# MPack: Global Memory Optimization for Stream Applications in High-Level Synthesis

*Jasmina Vasiljevic and Paul Chow*

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# Introduction

- Automated on-chip memory optimization
- Stream applications on FPGAs:
  - Use lots of memory
  - Steady and predictable data accesses

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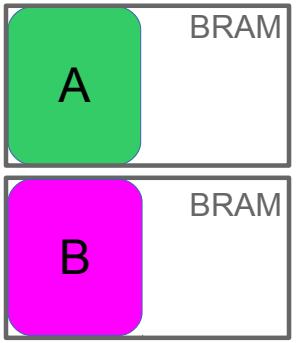
- Automated on-chip memory optimization
- Stream applications on FPGAs:
  - Use lots of memory
  - Steady and predictable data accesses
- *Buffer dimensions* do not always match *BRAM dimensions*
  - Result in low memory utilization
- *Buffer packing* can increase utilization
- Trade-off between *throughput* and *BRAM use*
  - Two *high-level MPack pragmas*

# Buffer Packing




*a) unpacked buffers*

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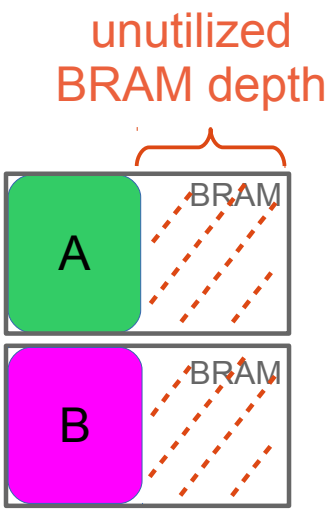


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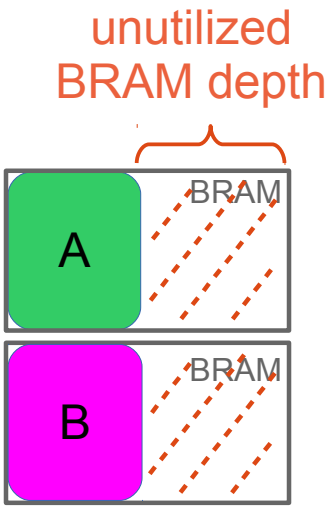


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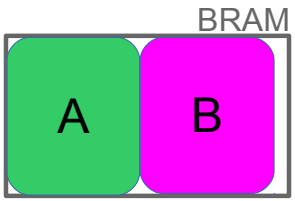


*b) horizontal packing*

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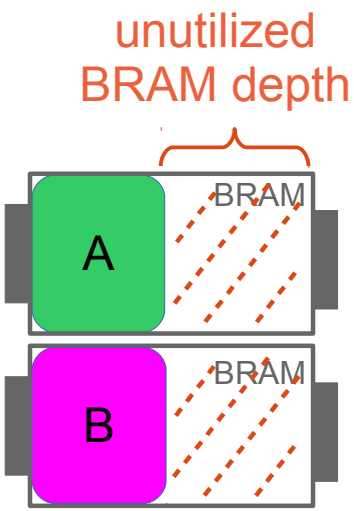


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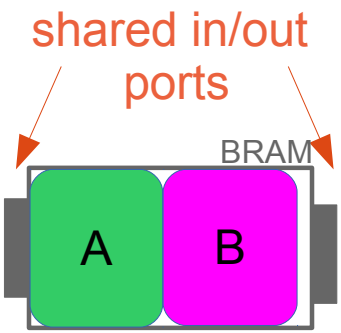


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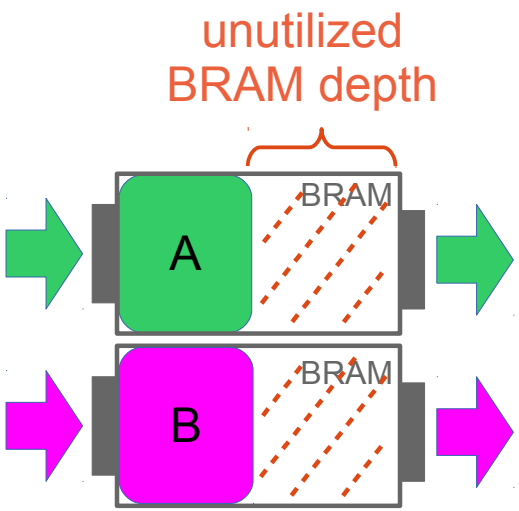


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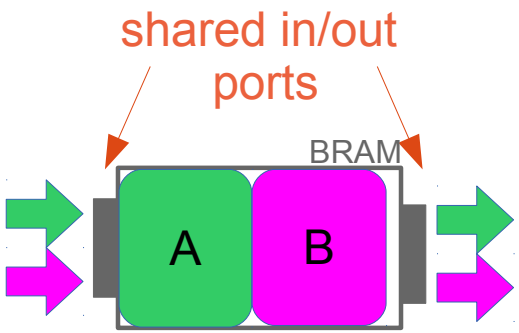


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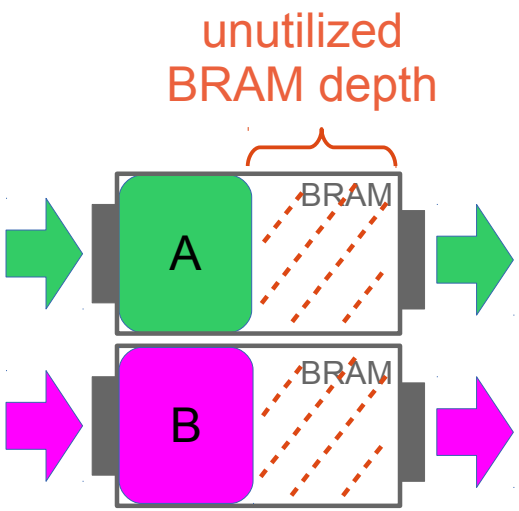


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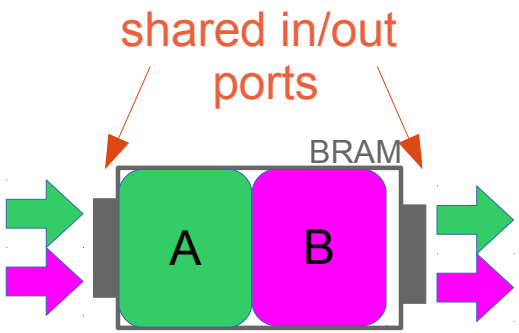
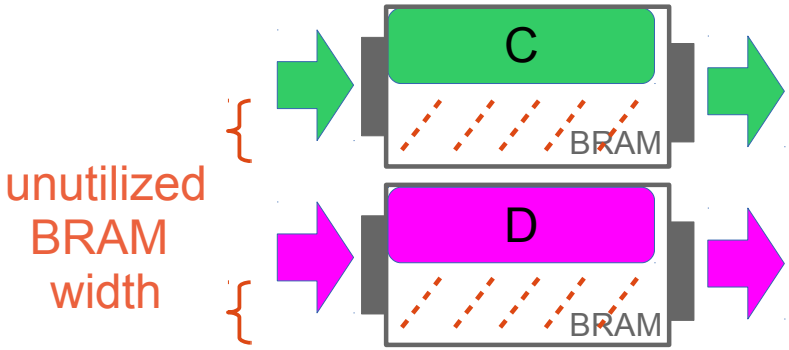
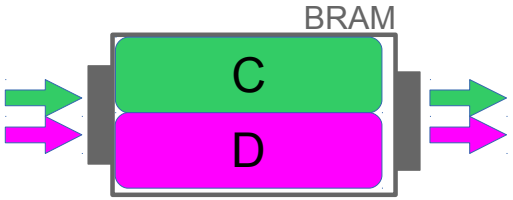



*b) horizontal packing*




*c) unpacked buffers*




*d) vertical packing*

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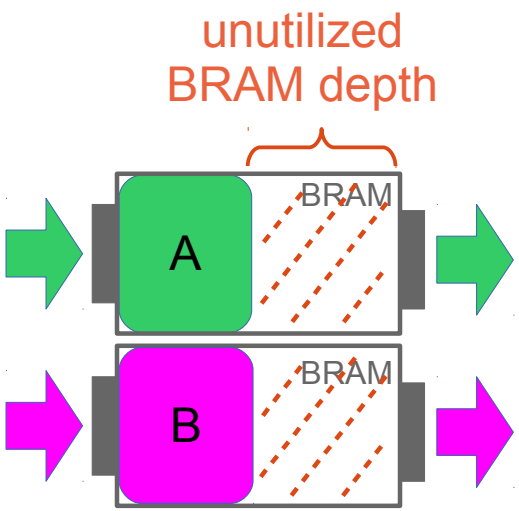


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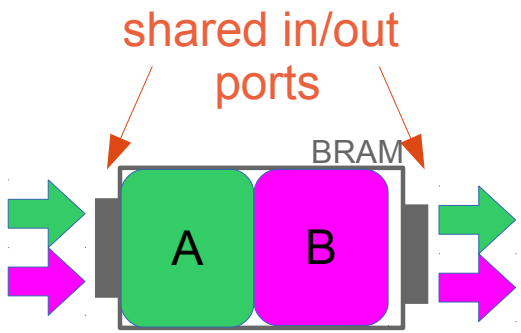
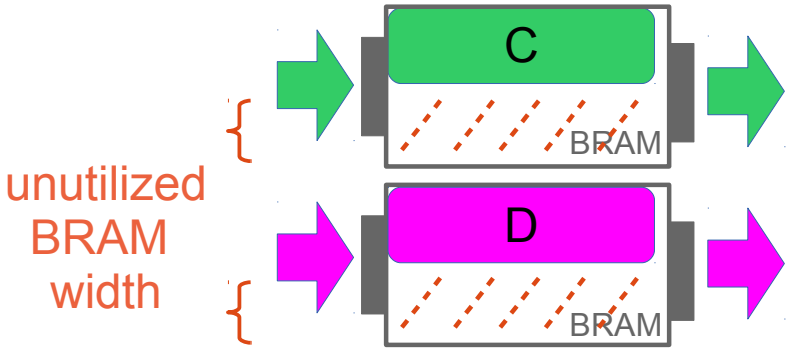



```
set_directive_array_map -instance AB -mode horizontal foo A
set_directive_array_map -instance AB -mode horizontal foo B
```

*b) horizontal packing*

XILINX
VivadoHLS
pragmas/directives

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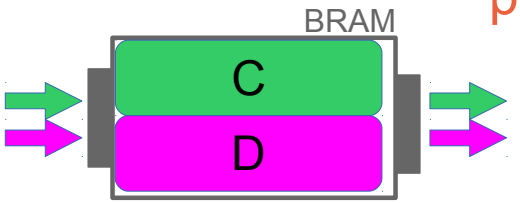


```
set_directive_array_map -instance AB -mode vertical foo A
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*d) vertical packing*

# Tool Flow

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| Name | Words | Bit-width |
|---|---|---|
| buffer1 | 100 | 9 |
| buffer2 | 500 | 9 |
| buffer3 | 700 | 16 |
| buffer4 | 1800 | 16 |
| buffer5 | 1800 | 16 |
| buffer2 | 500 | 9 |
| buffer3 | 700 | 16 |
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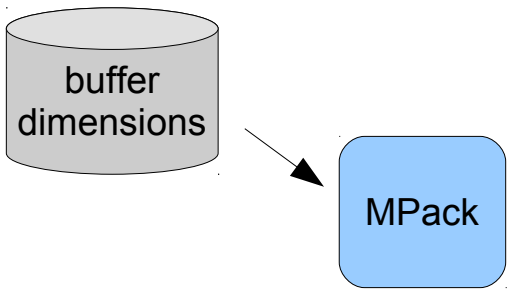

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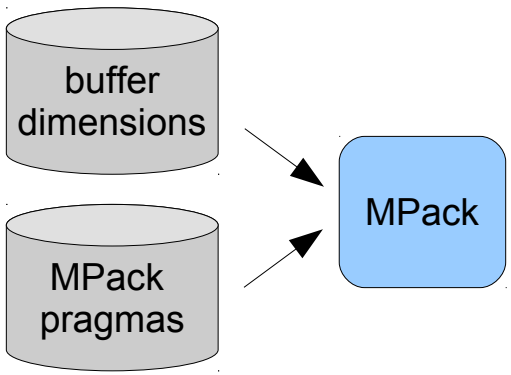


*High-level MPack Pragmas:*

`mpack_system_thr`

OR

`mpack_brams`

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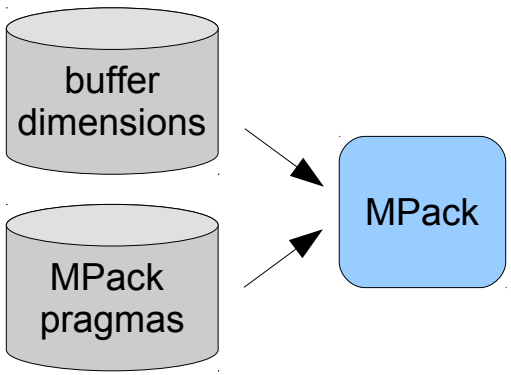
- Brute force optimization
- All buffer packing combinations

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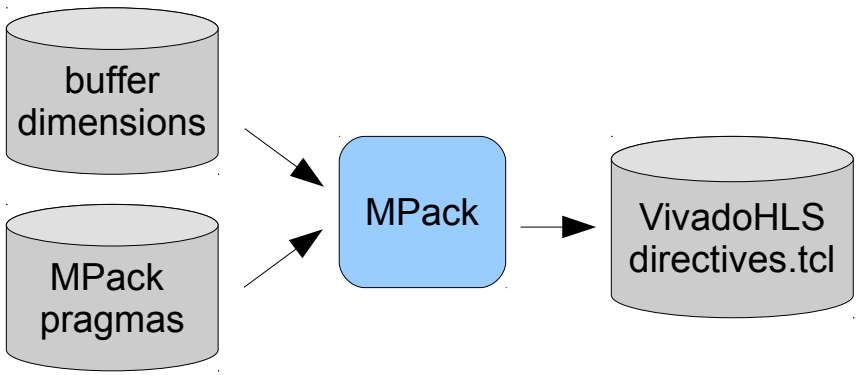


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*set_directive_array_map -instance AB -mode horizontal foo buffer1*
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*set_directive_array_map -instance C -mode vertical foo buffer3*
*set_directive_array_map -instance C -mode vertical foo buffer4*
*set_directive_array_map -instance D -mode horizontal foo buffer5*
*set_directive_array_map -instance D -mode horizontal foo buffer6*
*set_directive_array_map -instance E -mode vertical foo buffer7*
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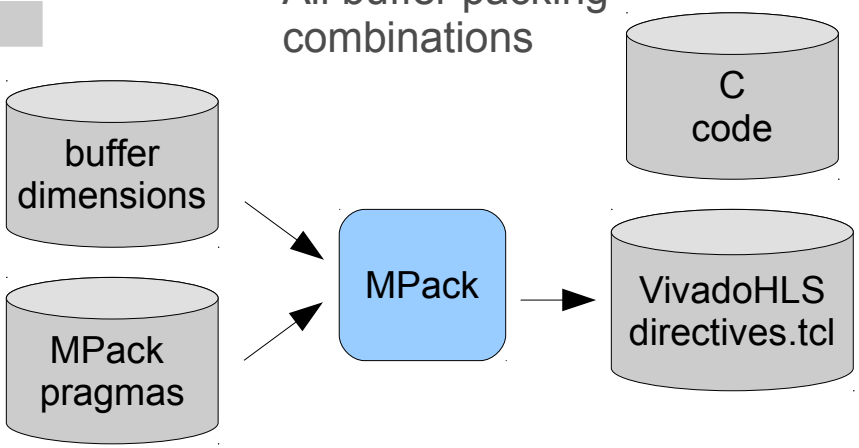


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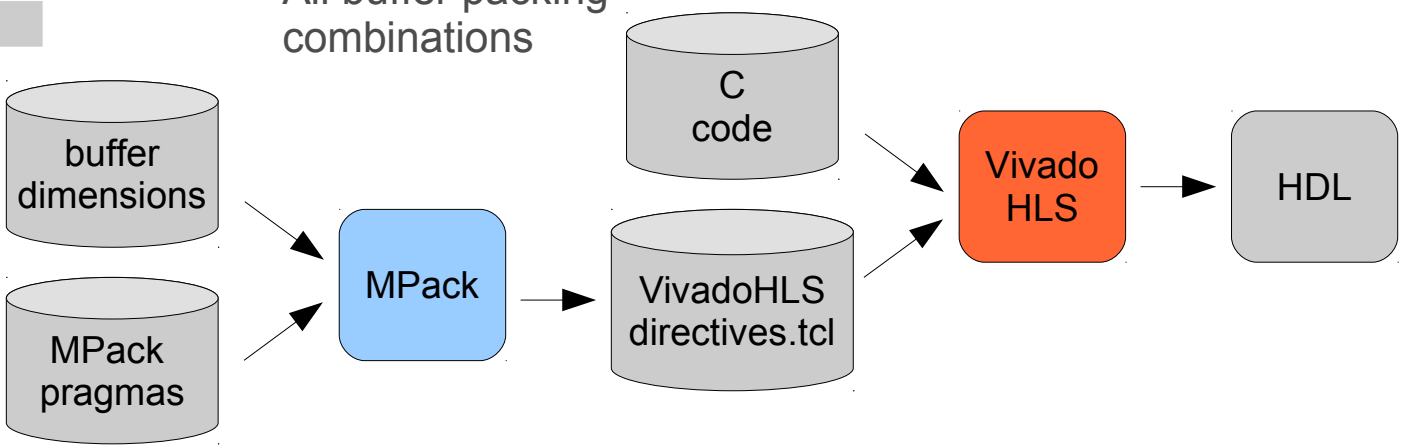


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# Results

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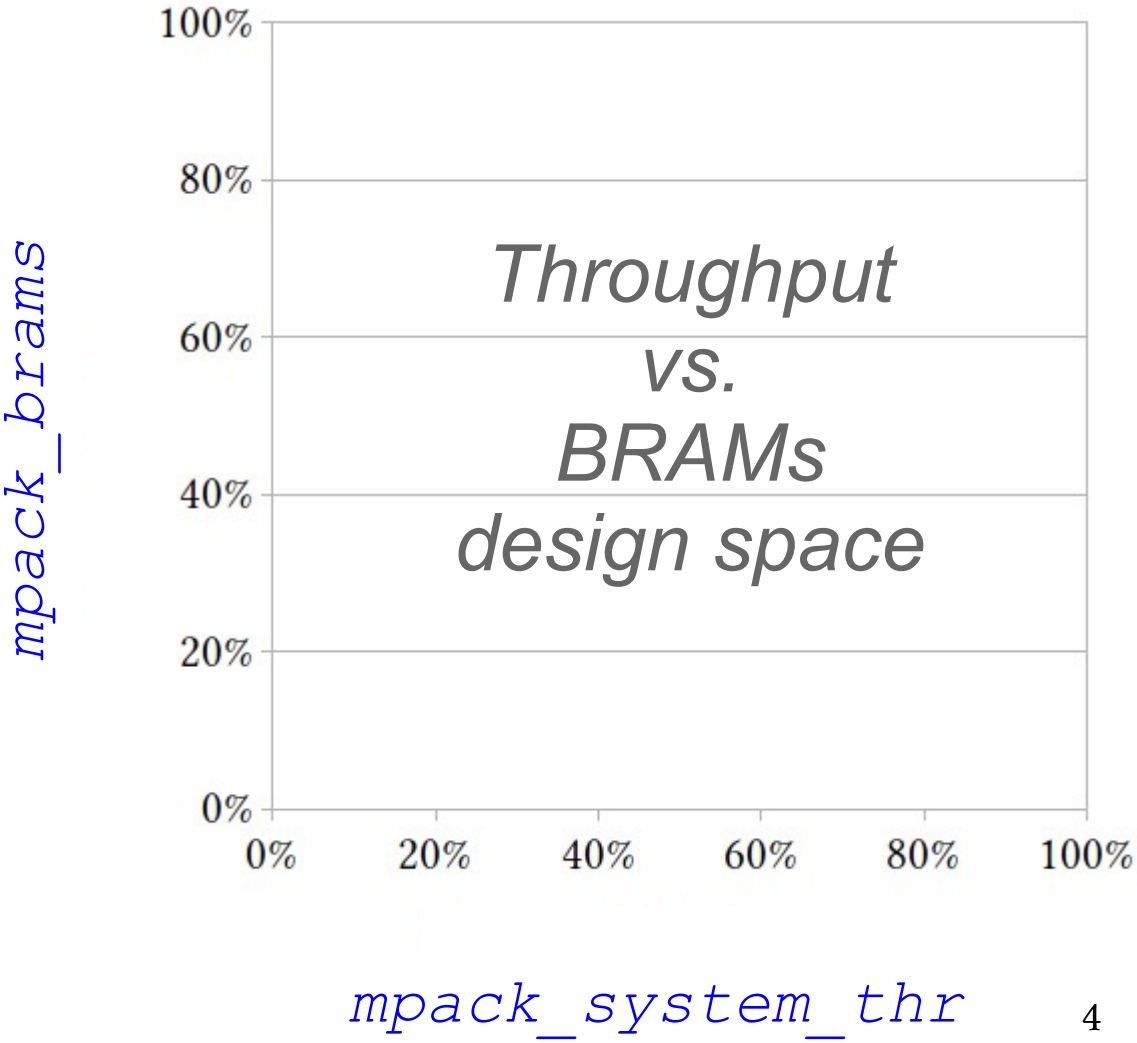
  1. `mpack_system_thr`
     - Data throughput of the entire design

  2. `mpack_brams`
     - The upper bound on BRAMs



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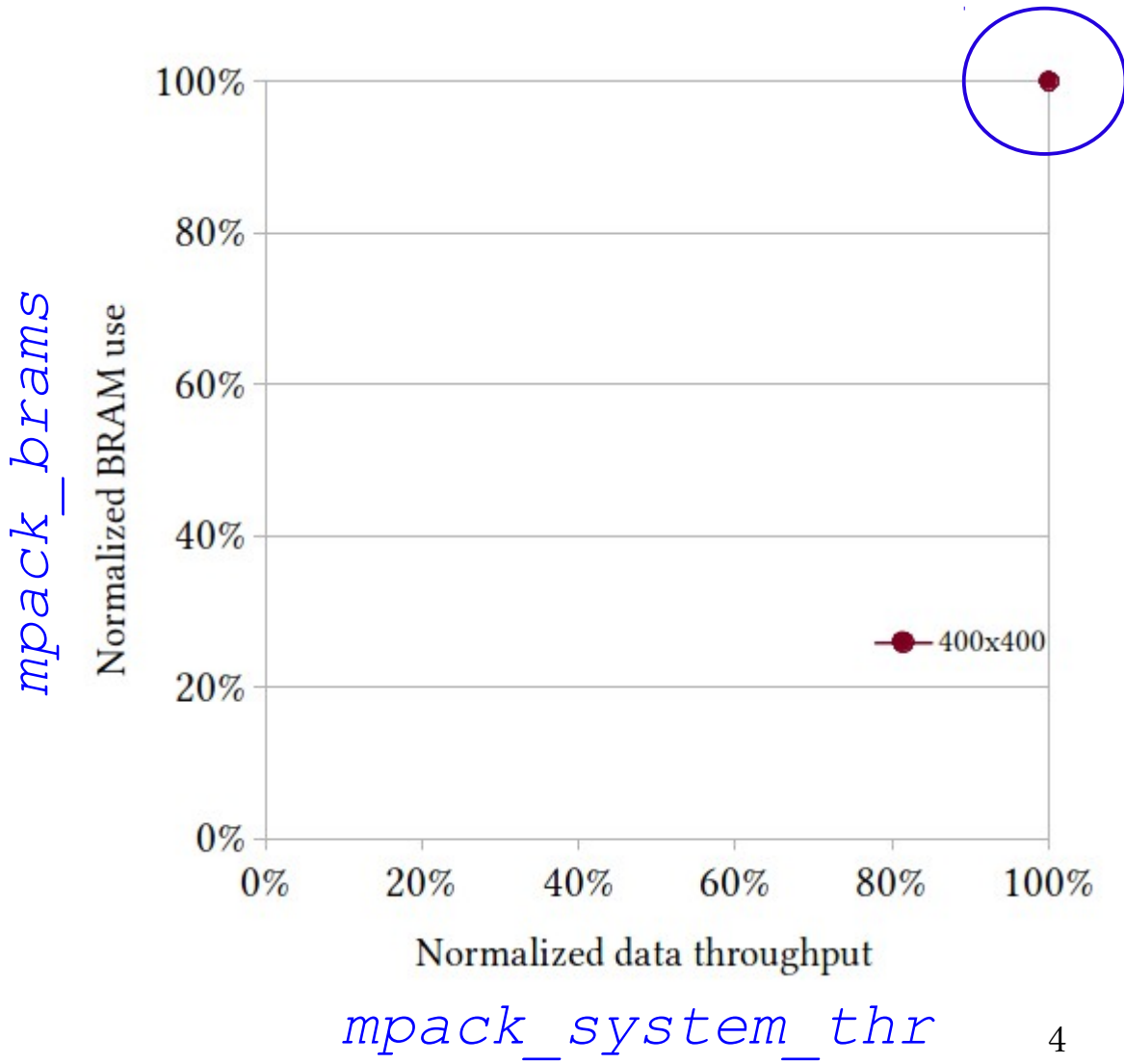

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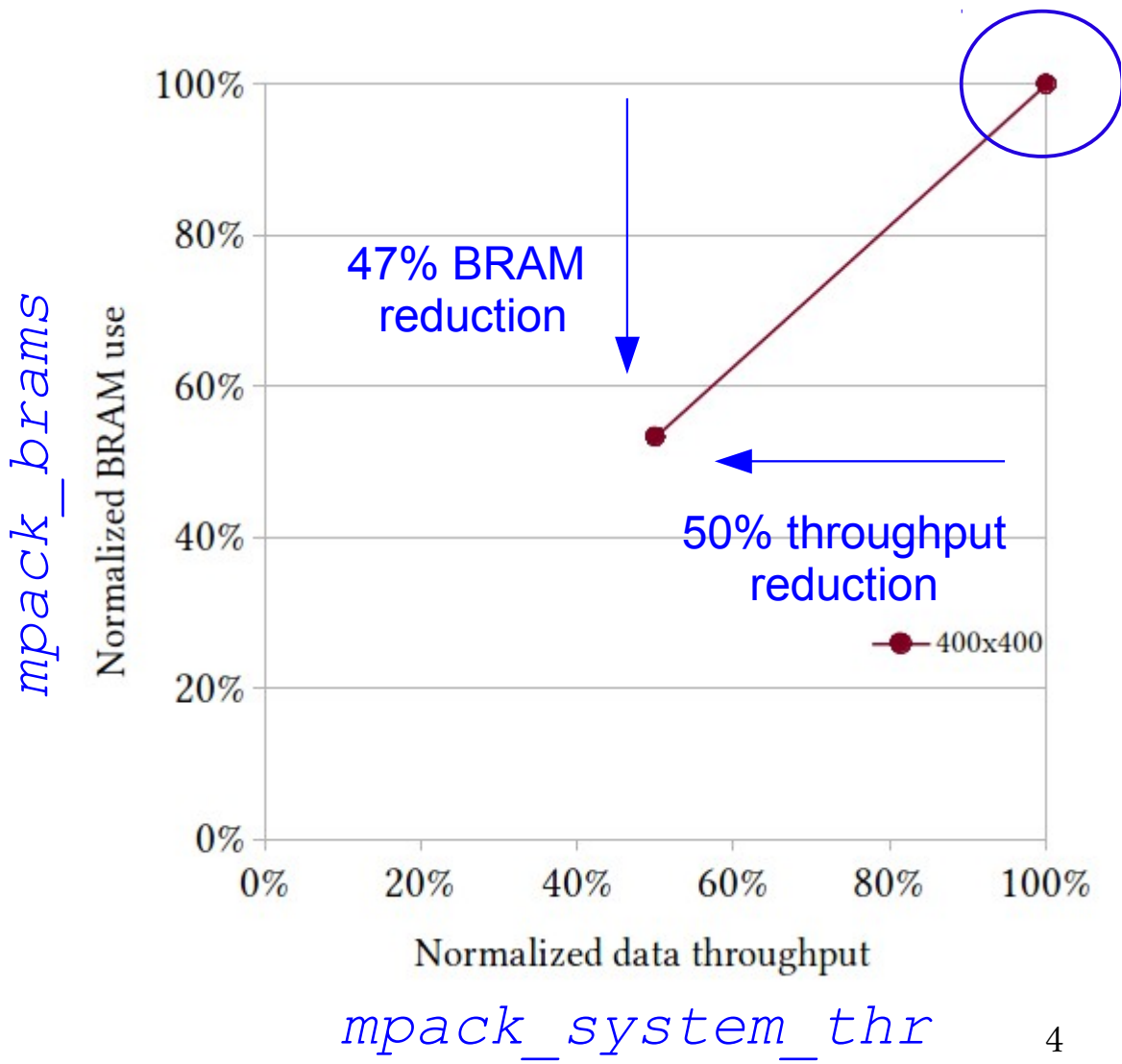

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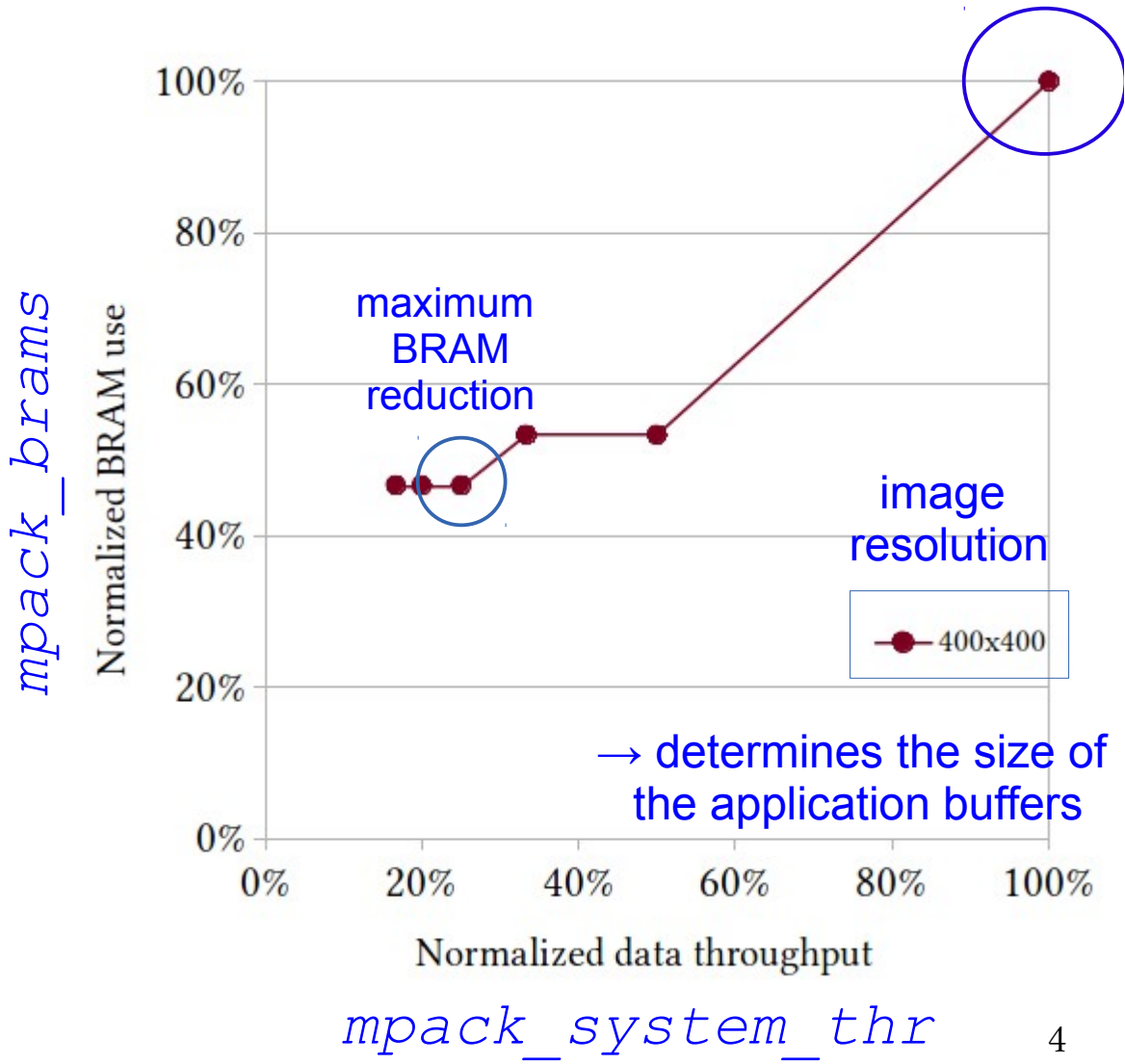

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- Default design
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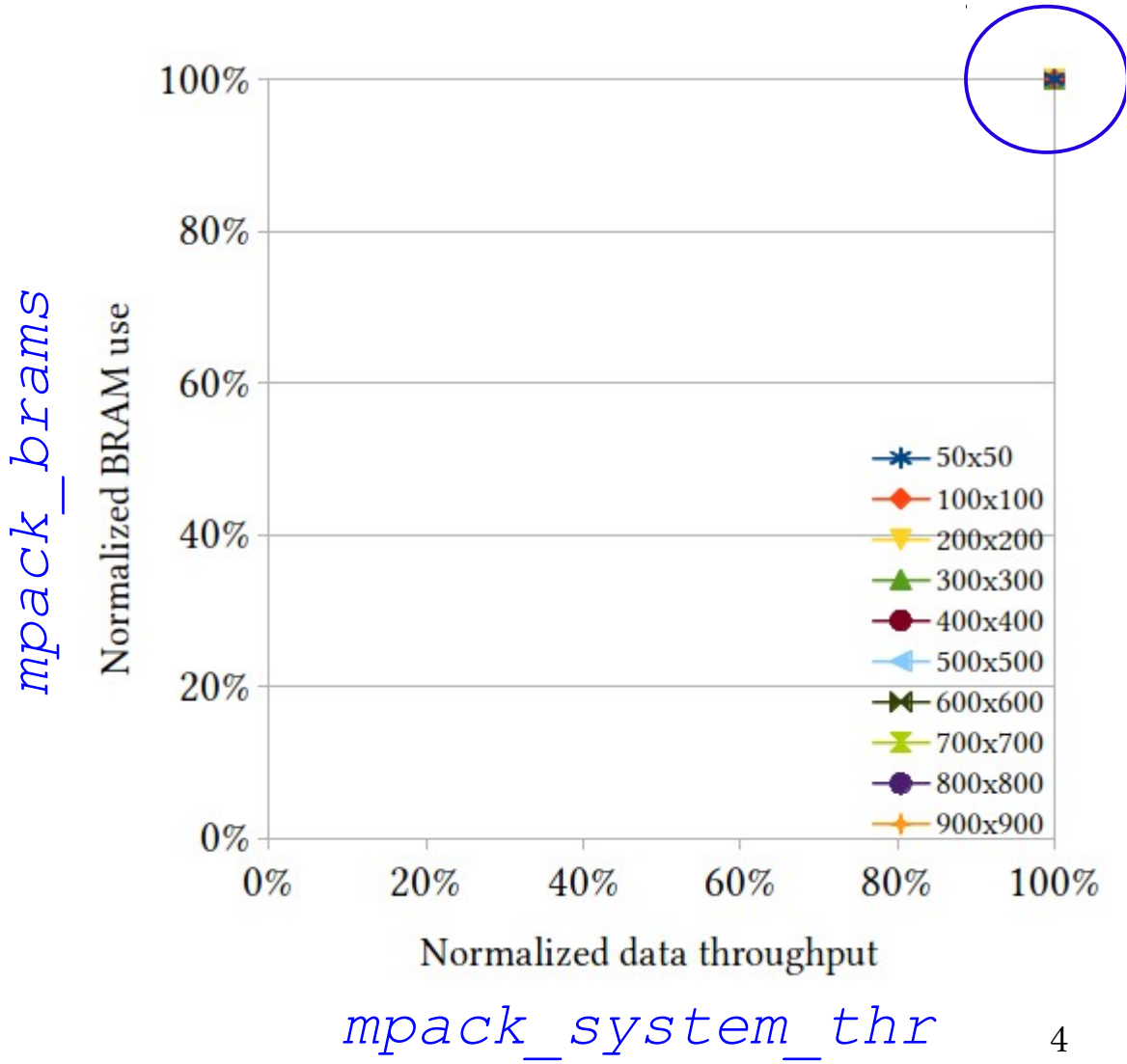

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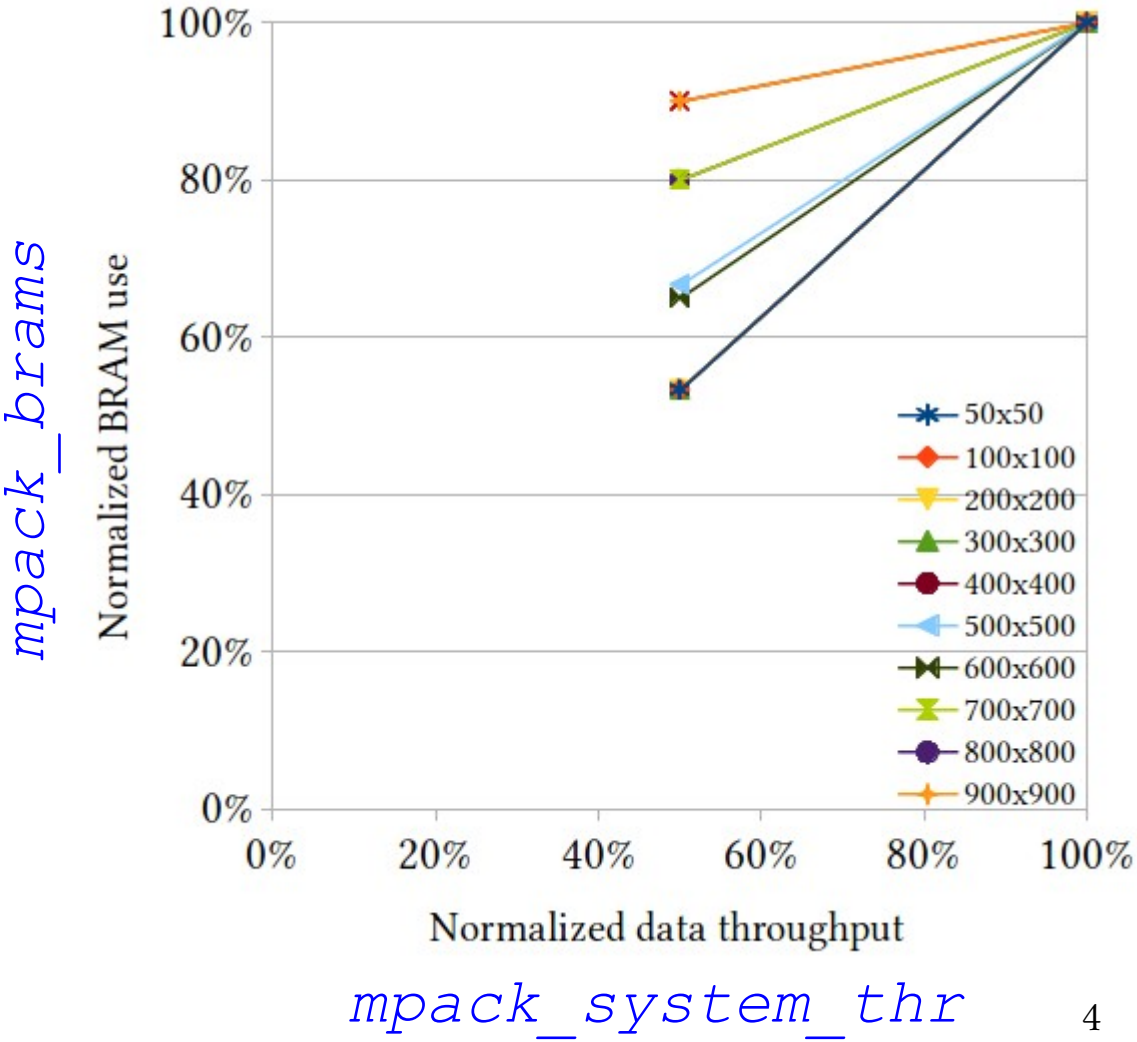

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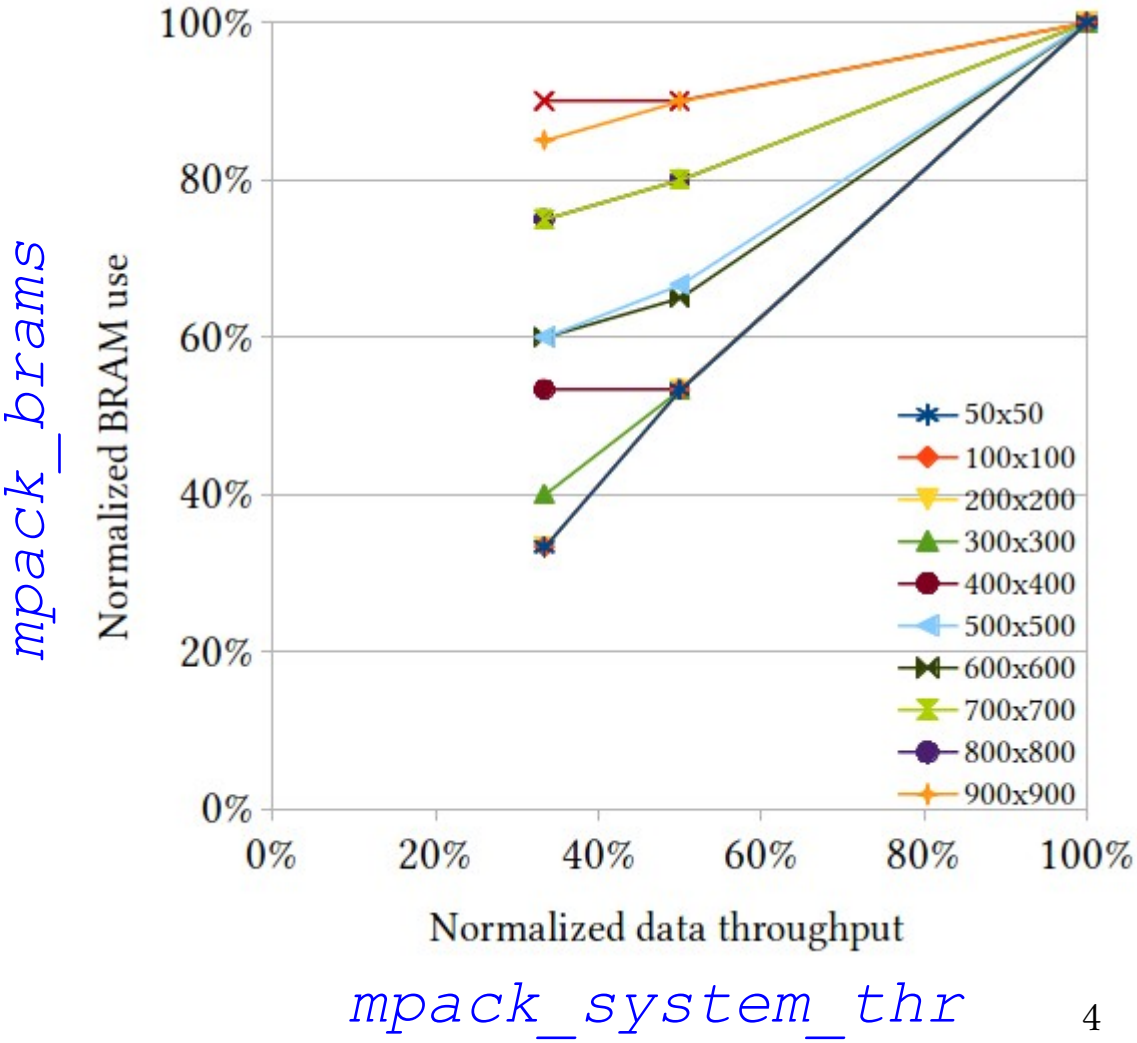

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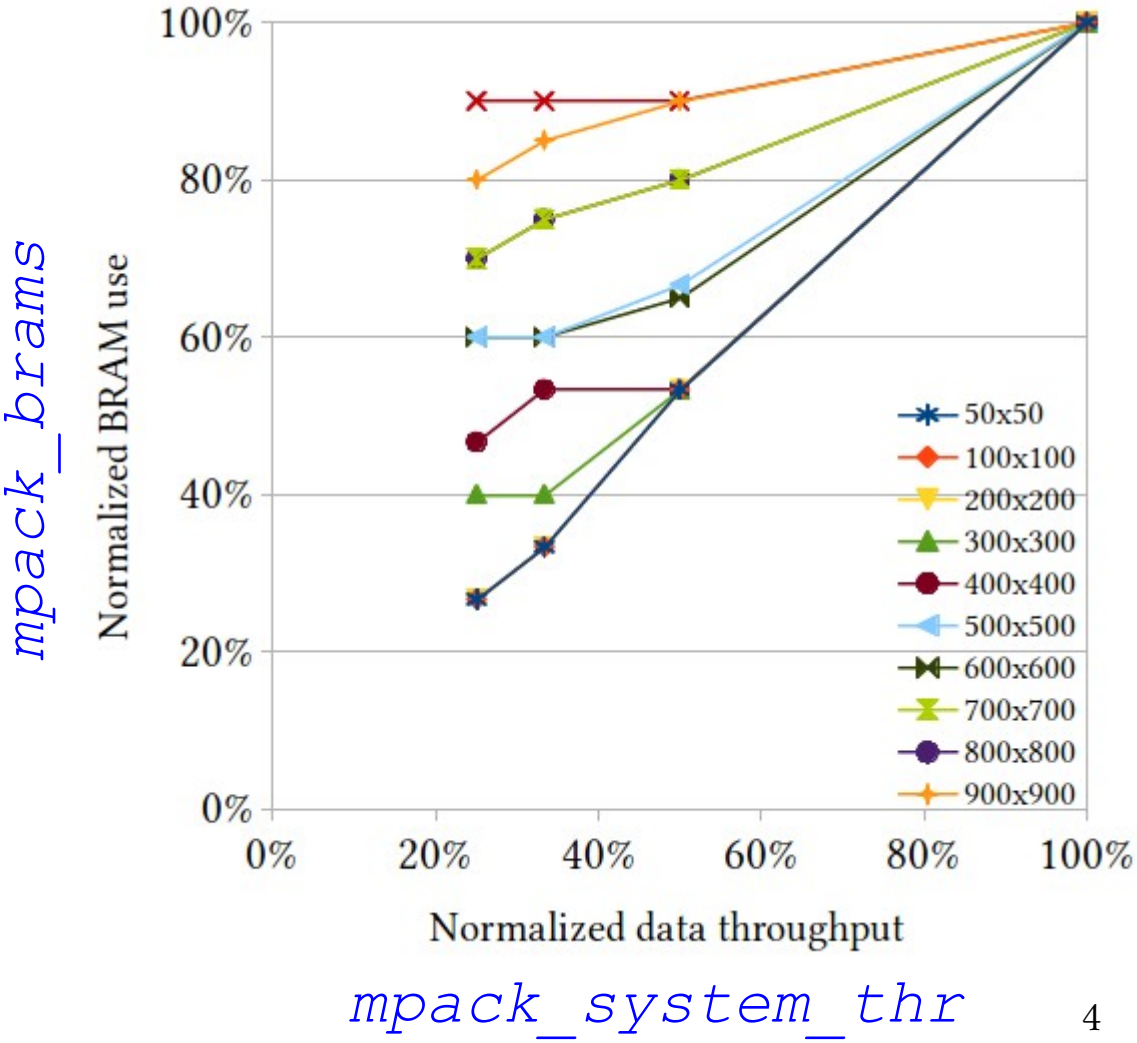

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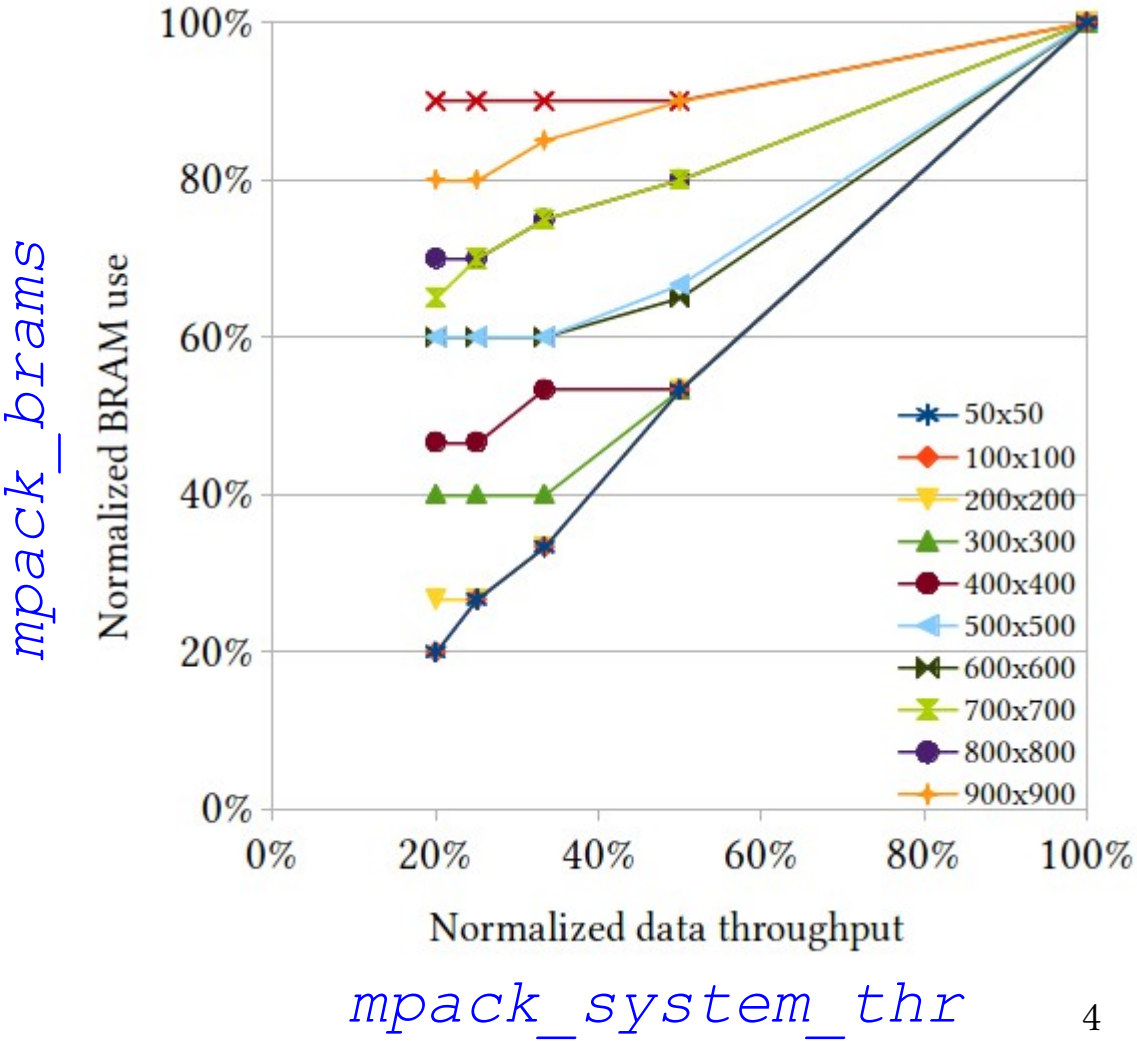

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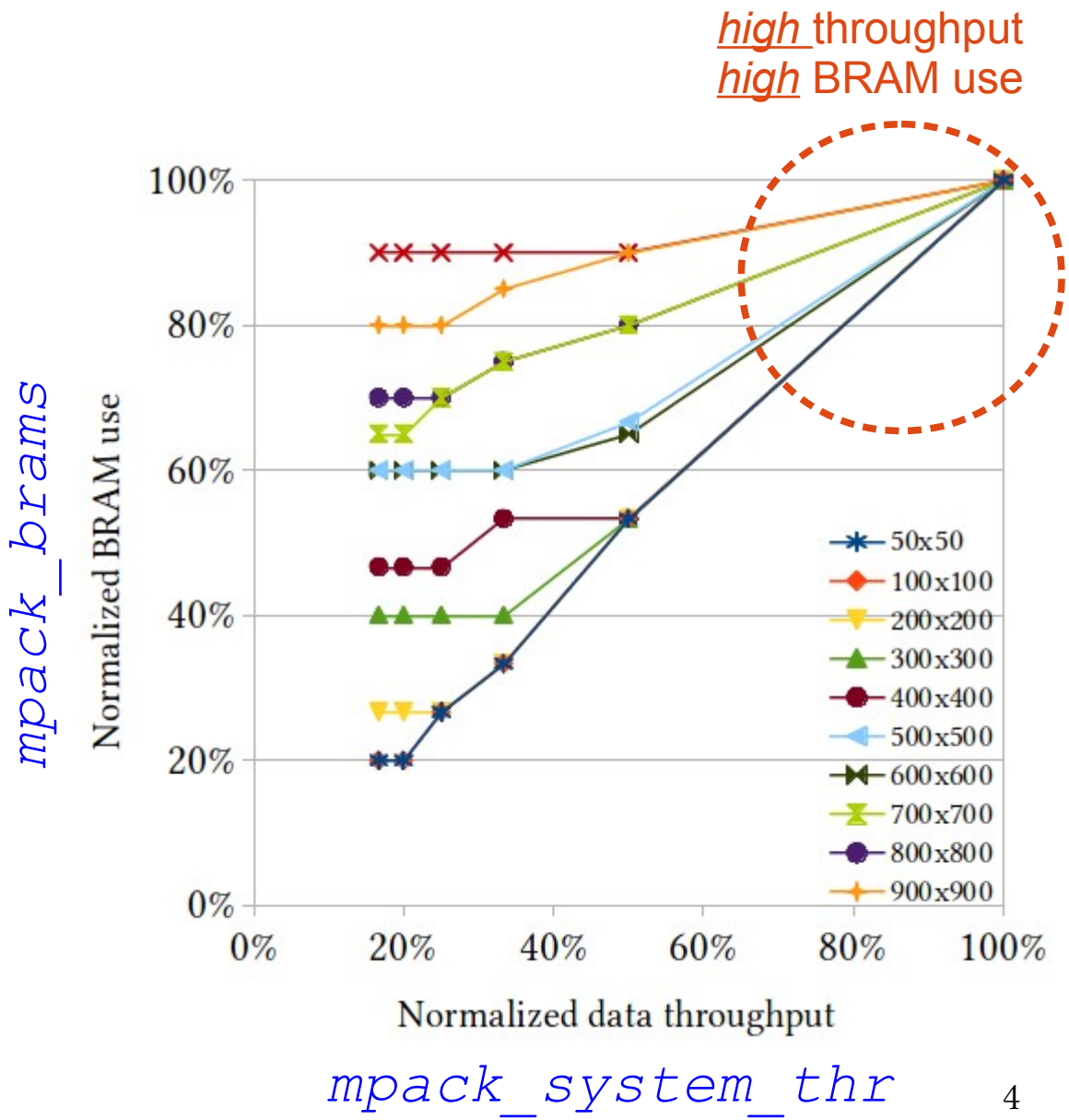

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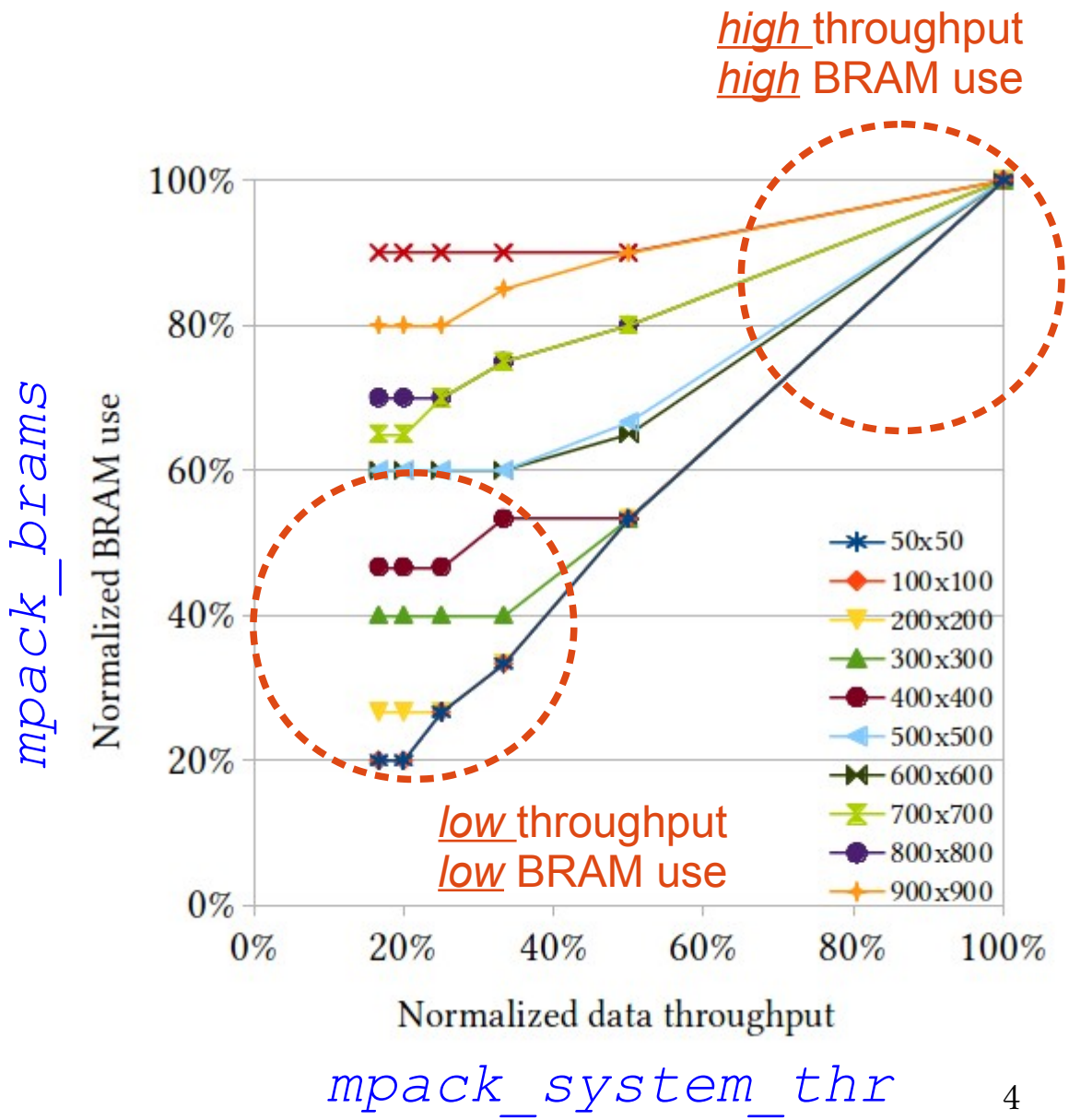

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- Future work
  - Using buffer partitioning to scale the throughput up
  - Improve packing algorithm
  - More buffer packing approaches
  - Low-level optimizations

*Thank you*