

CachePool: Many-core cluster of customizable, lightweight scalar-vector PEs for irregular L2 data-plane workloads

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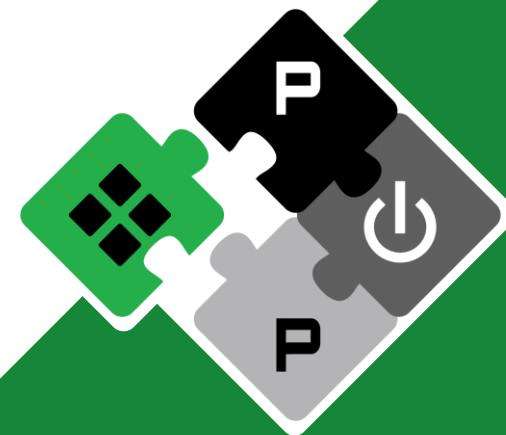
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Outline

- **Recall: RLC packet handling and control**
- **Proposed possible micro-kernels**
 - RLC packet handling
 - RLC control
- **Requested additional information**
- **Open discussions**



Recall: RLC Packet Handling and Control



- **RLC Packet Handling**

- Massive **unstructured sparse data handling** in double **linked-list** format
- No data dependency between different users
- **Minimum** calculation overhead
- Need **buffer** for ACK retransmission handling
- Hard or impossible to utilize vector instruction

- **RLC Control**

- Mixed scalar/vector instruction (40%-60%)
- Need to support different types of INT (8, 16, 32, 64)
- FP support is not needed



Reasons for Micro-Kernel Extraction



- **What is a (micro-)kernel?**

- Fundamental building blocks or operations for a specific workload or algorithm, e.g. matmul

- **Why we need them?**

- Decoupling the workload chain into several key tasks can reflect the application performance.
- We need some standard results to evaluate our architecture design.

- **How do we use them?**

- Ideally, a large algorithm/workload can be decomposed into a **chain of kernels**
 - E.g. PUSCH OFDM-BF-MIMO-CHE-NE can be transferred into FFT-MatMul-Cholesky Decomposition-Division-Autocorrelation
- If not possible, we can still use them to **evaluate** the most critical parts of the workload.
 - Extremely helpful in early development phase of the architecture design.
 - Helpful to tune some **architecture design choices/parameters**.



Micro-Kernel Extraction



Based on our readings and understandings in the last month, we propose several possible related kernels following these criteria:

- **RLC Packet Handling**

- This part can be abstractly treated as operating on several large **linked-lists** corresponding to different users, where each node is a packet sent.
- We treated the workload as **traversing through the linked-list**, **dissecting** one node into several nodes depending on the output payload size, and **retransmitting** if needed.

- **RLC Control Algorithm**

- The control part is an **optimal value finding problem** limited by two constraints and is divided into two algorithm of iterative power allocation and resource allocation.
- We plan to separate the control part from the packet handling for now, treating them as two **independent** problems to solve by one architecture.
- We extract several **key operations** from the algorithm as the kernels.



Possible Micro Kernels – RLC Packet Handling



- **Linked List**

- Description

- Randomly generate a large linked list with random payload size.
 - There are various variants for this kernel, such as sorting/inserting/reassembling using several cores.
 - Can integrate some operations on the payload into it, e.g. carry out a dotp/axpy on the payload data.
 - More complex linked list structure is possible, e.g. a list of the lists (double linked list)

- Usage

- Cache performance and coherence test.
 - A good reference kernel for RLC packet handling.



Possible Micro Kernels – RLC Packet Handling



- **Pointer Chasing**

- Description

- An important variant of Linked List kernel. Traverse the list and sum the value.
 - Standard test used for DRAM performance, can also be adapted for cache test.
 - Linked list can be placed in different memory hierarchy for different testing purpose.

- Usage

- Cache performance and coherence test.
 - Cache miss handling policy.



Possible Micro Kernels – RLC Control



- **Sparse Matrix-Vector Multiplication (SpMV)**

- Description
 - A standard test for sparse data handling.
 - Matrix-vector multiplication between a sparse matrix and a dense vector.
 - Can be vectorized.
- Usage
 - (Many-core) vector PE performance analysis
 - Cache performance evaluation on (un)structured sparse data

- **Maximum Value Sorting**

- Description
 - Built upon the linked-list kernels, finding the maximum value from an array/linked-list.
- Usage
 - *argmax* function in the control algorithm



Possible Micro Kernels – RLC Control



- **Logarithm Calculation Using Taylor Expansion**

- Description

- Taylor expansion: $\log(1 + x) \approx x - \frac{x^2}{2} + \dots + \frac{(-1)^{n+1}x^n}{n} + \dots = \sum_{n=1}^N (-1)^{n+1} \frac{x^n}{n}$

- Usage

- $\log(1 + p \cdot g)$ in the control algorithm.

- **Sum Reduction**

- Description

- Summation across a large number of cores.
 - Can be integrated into some other performance testing kernels, like dotp.

- Usage

- Widely used in the control algorithm.



Requested Additional Information



	Payload Size (# and type of element)	List Depth / Length	Sparsity Level & Addr. Range	Parallel Handling? Vectorized ops?	Data Transfer Bandwidth	TTI
Linked List	Size range of each node’s data (packet size range).* The operation load needs to be done on each payload.	# of packets each user sent	Addr. range of all users; addr allocation policy for new packet.	# of users handled in parallel	e.g. packet arrival rate and size from upper chain, and the output rate to the lower chain	TBD
Pointer Chasing						TBD
(Opt) SpMV	Matrix/Vec size and data format (CSR, CSC, COO)	N/A	Structured types / Unstructured	How’s the data dependency across the inputs of the control part? Is it efficient to calculate it using many-core? Which parts are expected to be calculated using vector instructions?	e.g. packet arrival rate, number of users, user’s request resources	TBD
Max Value Sorting	Data type and precision (int8/16/32/64)	Array size of control input	We do not fully understand the in-outputs of the control part. Are they the same sparse linked-lists as the packet handling?			TBD
Log Calc.	Precision (order of Taylor)					TBD
Sum Reduction	Data type and precision (int8/16/32/64)					TBD



Open Discussions

- **Understandings on the RLC**
 - Packet handling
 - Control
- **Kernel extractions**
 - Proposed kernels
 - Kernel parameters
 - Kernel suggestions
- **Next meeting schedule**



Thank you!

Q&A

