

Exploring and Quantifying How Communication Behaviors in Proxies Related to Real Applications



PRESENTED BY

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What are proxies?

- They are relatively small programs that attempt to:
 - Capture fundamental aspects of a real scientific application

Can we measure fidelity?

- How similar is a proxy to its parent?

What category of measurement to measure similarity?

- I/O
- HW performance (previous work)
- Communication

In this work we choose to focus on communication



What **analysis** fits this work?

1. Pairwise communication data analysis

- Point to point communication patterns (source, destination)
- Total number of messages sent for each pair
- Using CrayPat tool

2. Communication vector data clustering

- KB/sec - Total size of data transferred (KB) / total execution time (sec)
- MPI KB/sec - Total size of data transferred (KB) / total time spent in MPI (sec)
- Message size histogram data
- Using mpiP tool



Capture point-to-point communicating MPI processes and the total number of calls between these points

- Number of messages sent from a specific source process (rank) to a specific destination process (rank)

Pairwise Pattern Data

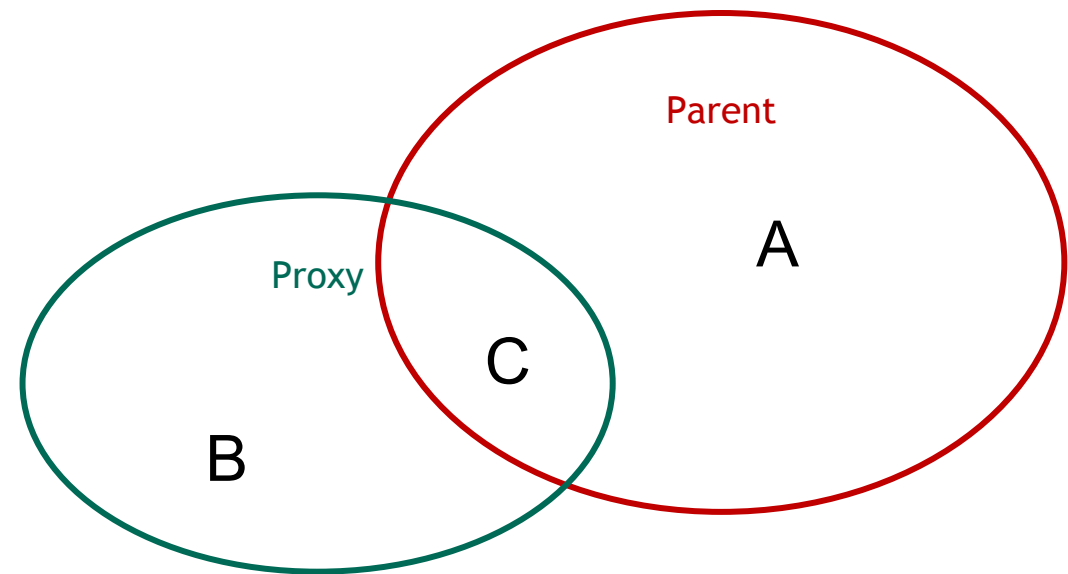
- (source, destination)

CrayPat toolset

Area A, Parent (Real) Communication Pairs

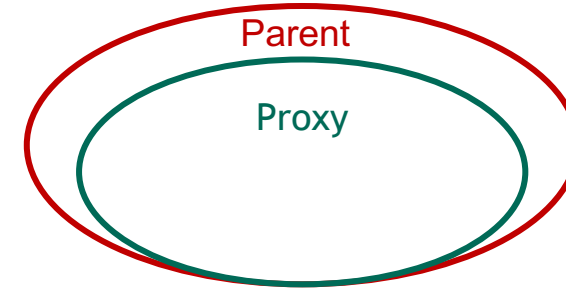
Area B, Proxy Communication Pairs

Area C, $(\text{Parent} \cap \text{Proxy})$ Communication Pairs

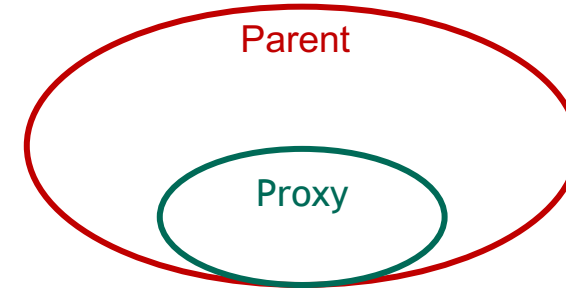




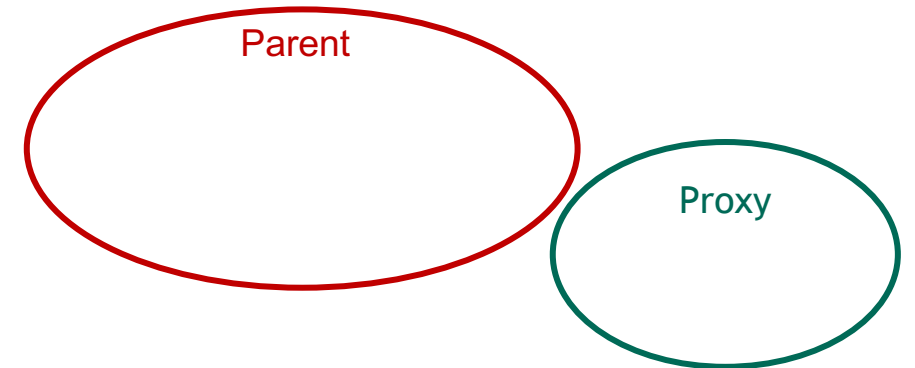
Proxy capturing **most** of the parent communication



Proxy capturing **some** of the parent communication



Proxy **NOT** capturing any of the parent communication



How to compare the Parent/Proxy patterns?

Proxy		
Src	Dst	#Msg
0	1	152120
0	10	153422
0	100	1302
68	64	13020
68	65	13020
68	67	153422
68	69	1302

Parent		
Src	Dst	#Msg
0	1	35046
68	64	86
68	67	62
68	69	5887
68	70	24
68	71	29090
68	75	34984
68	91	5916



How to compare the Parent/Proxy patterns?

Solution: Create **THREE** data sets

- **Set 1**, Parent filtered by Proxy
 - Eliminates extra communication in the parent (that's not in the proxy); parent and proxy have same communicating pairs, but may have different message #s
- **Set 2**, Proxy filtered by Parent
 - Eliminates extra communication in the proxy (that's not in the parent); parent and proxy have same communicating pairs, but may have different message #s
- **Set 3**, Full augmentation for both

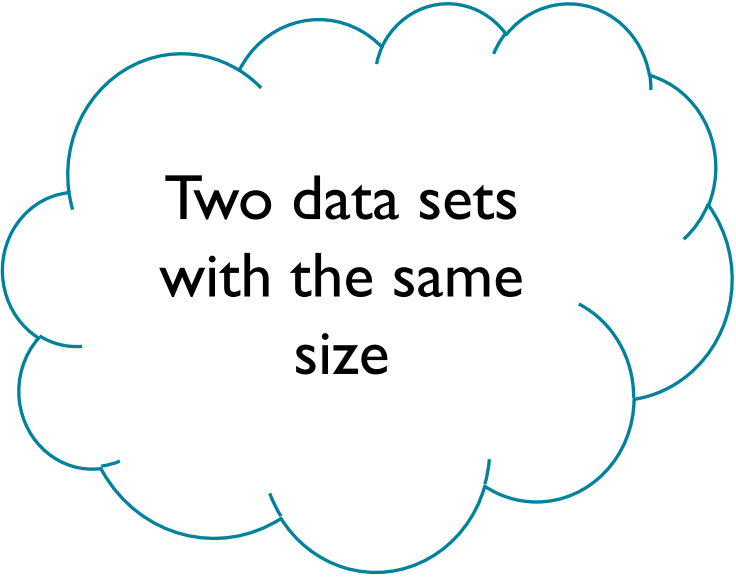


Two data sets
with the same
size

Proxy		
Src	Dst	#Msg
0	1	152120
0	10	153422
0	100	1302
68	60	13020
68	65	13020
68	67	153422
68	69	1302



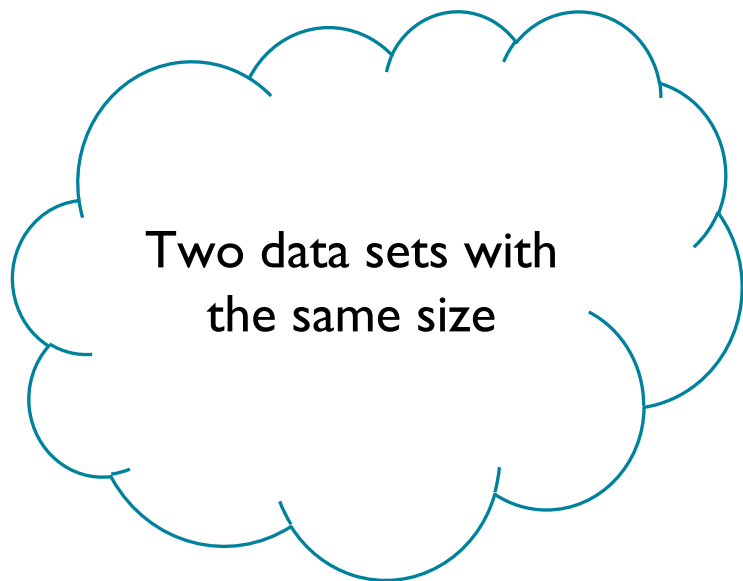
Parent		
Src	Dst	#Msg
0	1	35046
0	10	0
0	100	0
68	60	0
68	65	0
68	67	62
68	69	5887



Two data sets
with the same
size

Proxy		
Src	Dst	#Msg
0	1	152120
68	64	0
68	67	153422
68	69	1302
68	70	0
68	71	0
68	75	0
68	91	0

Parent		
Src	Dst	#Msg
0	1	35046
68	64	86
68	67	62
68	69	5887
68	70	24
68	71	29090
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Proxy		
Src	Dst	#Msg
0	1	152120
0	10	153422
0	100	1302
68	60	13020
68	64	0
68	65	13020
68	67	153422
68	70	0
68	71	0
68	75	0
68	91	0

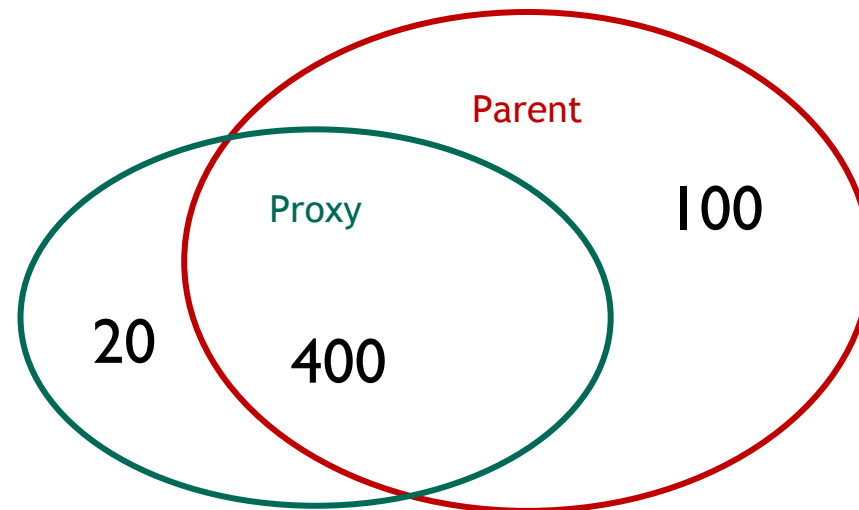


Parent		
Src	Dst	#Msg
0	1	35046
0	10	0
0	100	0
68	60	0
68	64	86
68	65	0
68	67	62
68	70	24
68	71	29090
68	75	34984
68	91	5916

Similarity Metrics: % Parent Covered by the Proxy



1. Percentage of parent communication that is covered by the proxy
 - by number of pairs



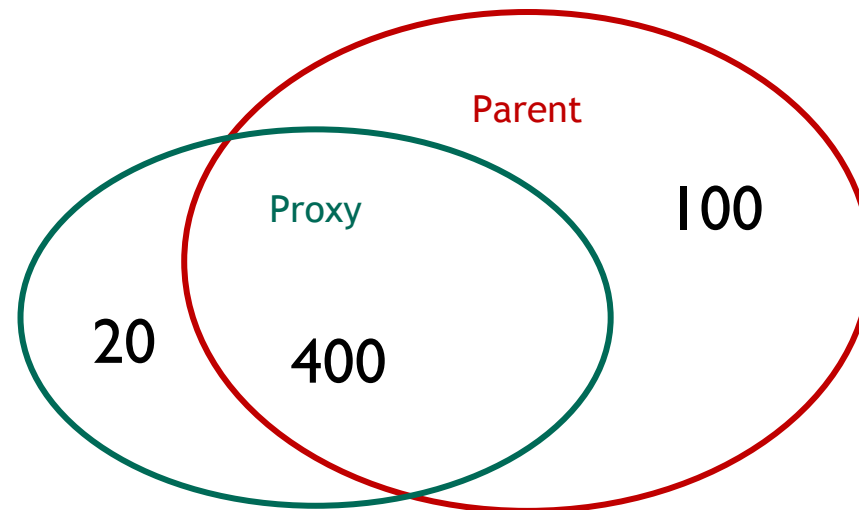
$$= 400/500 * 100$$
$$= 80\%$$

Similarity Metrics: % Proxy Covered by the Parent



2. Percentage of proxy communication that is covered by the parent

- by number of pairs



$$= 400/420 * 100$$
$$= 95\%$$

Similarity Metrics: Correlation Metrics Comparing



Compare the full sets of pairwise communication data in the parent and proxy

Compare that part of the parent's communication that matches the proxy

Compare that part of the proxy's communication that matches the parent

Used:

- **PEARSON CORRELATION**
- **SPEARMAN CORRELATION**



List of the Proxy and real applications used in this work:

Proxy	Version	Parent	Version	
SW4lite	2.0	SW4	2.0	Seismic modeling
Nekbone	3.1	Nek5000	17	Thermal transport
SWFFT	1.0	HACC	1.0	Cosmology/FFT
ExaMiniMD	1.0	LAMMPS	17 Aug 2017	Molecular dynamics



Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
LAMMPS/ ExaMMD	100	100	100	100	0	0	0	0	0	0
Nek5K 2D/ Nekbone 2D	99.9	57.4	37.5	62.8	0	0.06	-0.47	-0.05	0.55	0.93
Nek5K 3D/ Nekbone 3D	99.9	51.4	58.0	68.4	-0.1	-0.05	-0.65	-0.23	0.04	0.49
SW4/ SW4lite	100	100	100	100	1	1	1	1	1	1
HACC/ SWFFT	51.7	29.4	71.4	71.4	0.58	0.31	0.61	0.28	0.87	0.81



#msg:

- $40995 / (\text{\#msgs originally in the parent}) * 100$

#pair:

- Pairs with non zero messages
- $3 / (\text{\#pairs originally in the parent}) * 100$

Parent		
Src	Dst	#Msg
0	1	35046
0	10	0
0	100	0
68	60	0
68	65	0
68	67	62
68	69	5887
Total		40995

Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
Parent/ Proxy	%	%	%	%	+1 to -1	+1 to -1	+1 to -1	+1 to -1	+1 to -1	+1 to -1

Pearson and Spearman

- Compare #messages

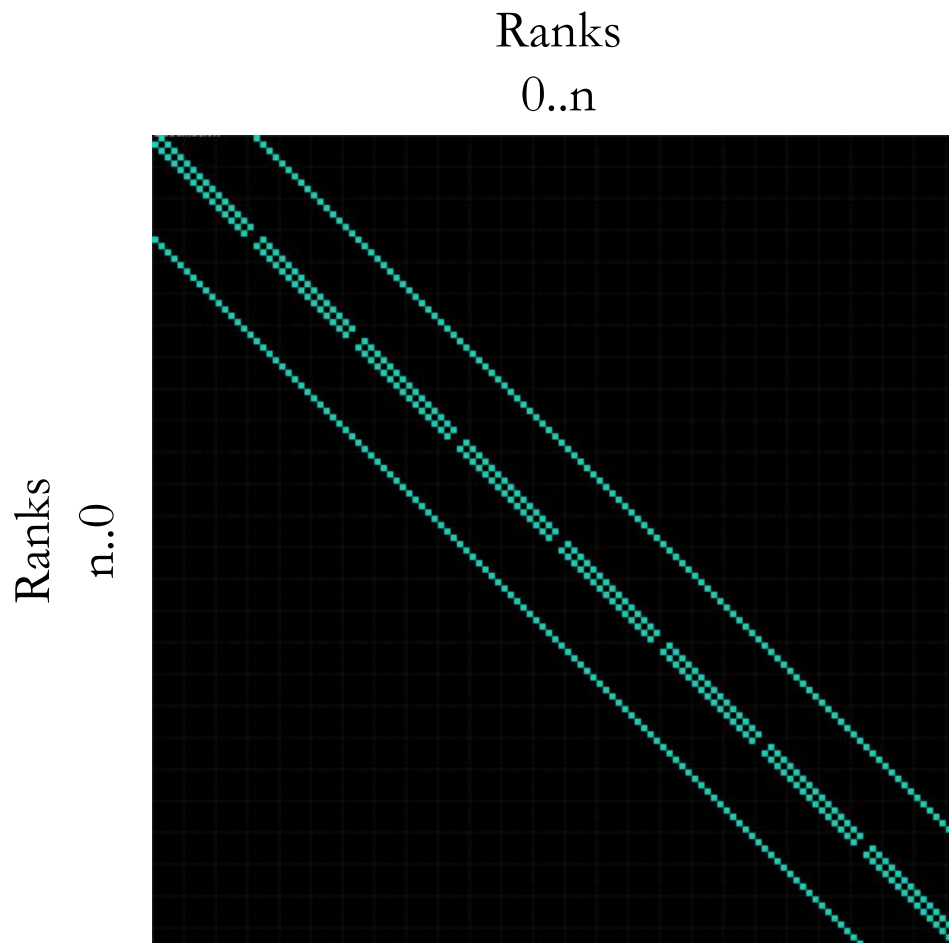
Proxy			Parent		
Src	Dst	#Msg	Src	Dst	#Msg
0	1	152120	0	1	35046
0	10	153422	0	10	0
0	100	1302	0	100	0
68	60	13020	68	60	0
68	64	0	68	64	86
68	65	13020	68	65	0
68	67	153422	68	67	62
68	70	0	68	70	24
68	71	0	68	71	29090
68	75	0	68	75	34984
68	91	0	68	91	5916

Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
Parent/Proxy	%	%	%	%	+1 to -1	+1 to -1	+1 to -1	+1 to -1	+1 to -1	+1 to -1

SW4 communication pattern

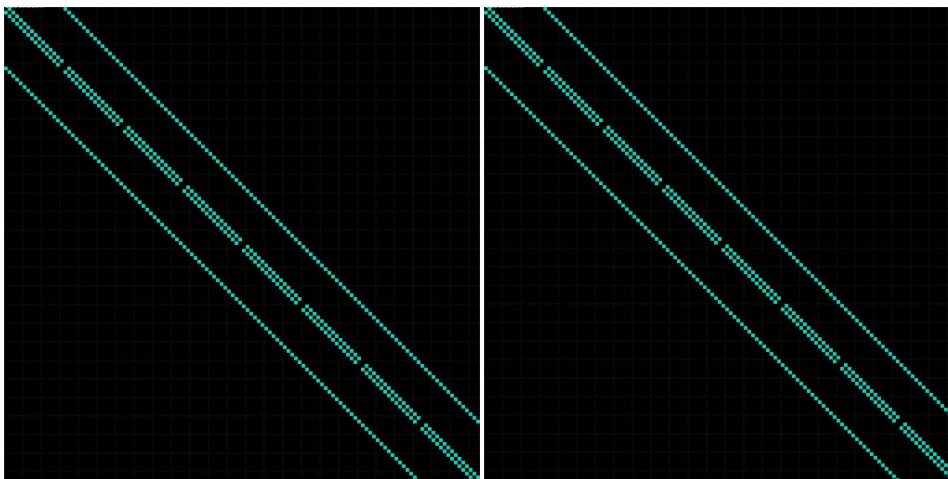


Density of number of messages
heatmap

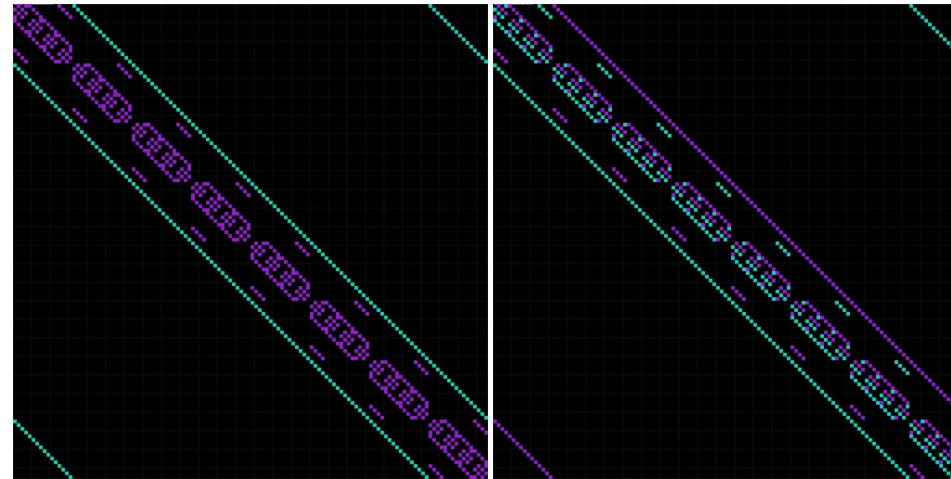


View of the communication
between the ranks

SW4 / SW4Lite

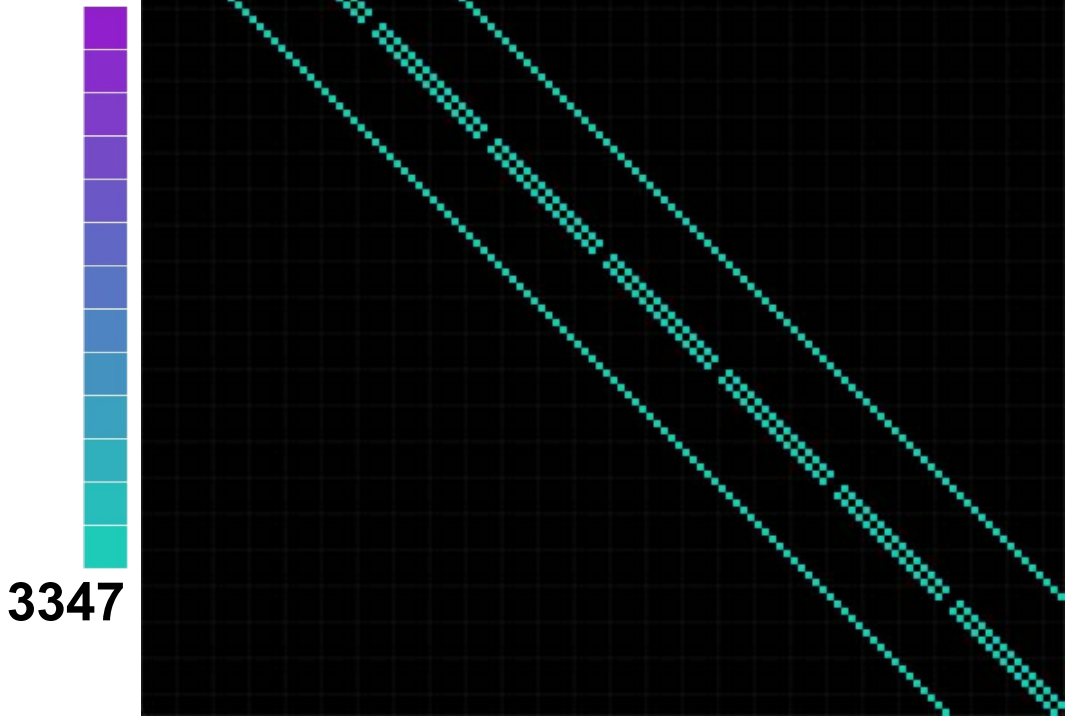


LAMMPS / ExaMiniMD

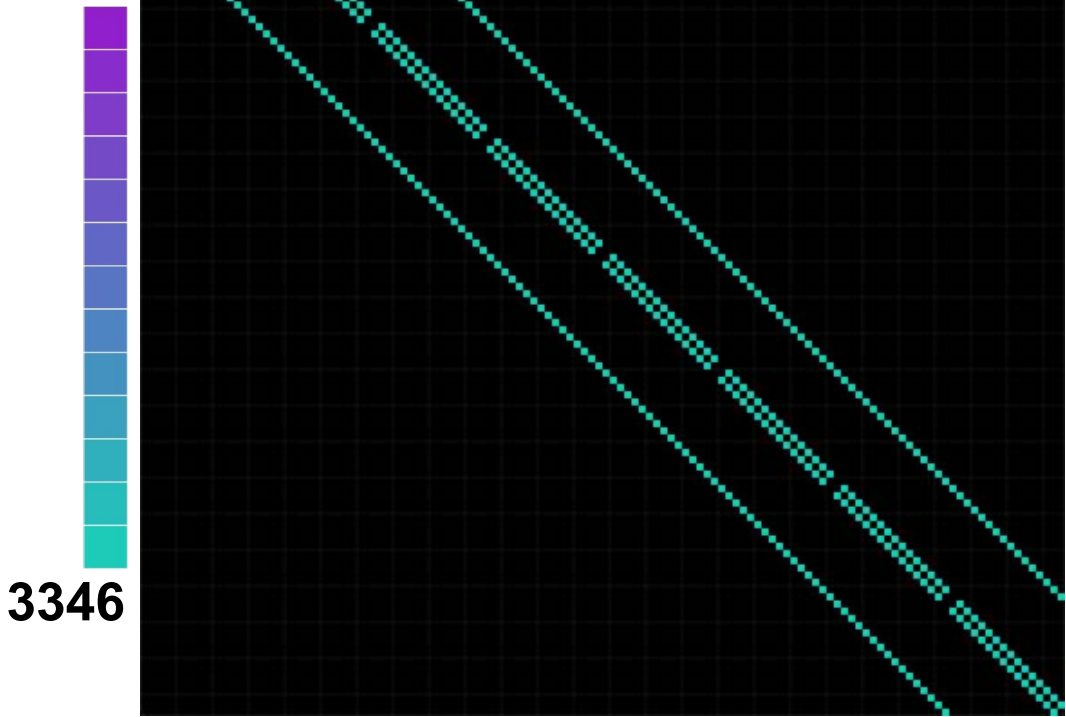


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
LAMMPS/ ExaMMD	100	100	100	100	0	0	0	0	0	0
Nek5K 2D/ Nekbone 2D	99.9	57.4	37.5	62.8	0	0.06	-0.47	-0.05	0.55	0.93
Nek5K 3D/ Nekbone 3D	99.9	51.4	58.0	68.4	-0.1	-0.05	-0.65	-0.23	0.04	0.49
SW4/ SW4lite	100	100	100	100	1	1	1	1	1	1
HACC/ SWFFT	51.7	29.4	71.4	71.4	0.58	0.31	0.61	0.28	0.87	0.81

SW4



SW4Lite

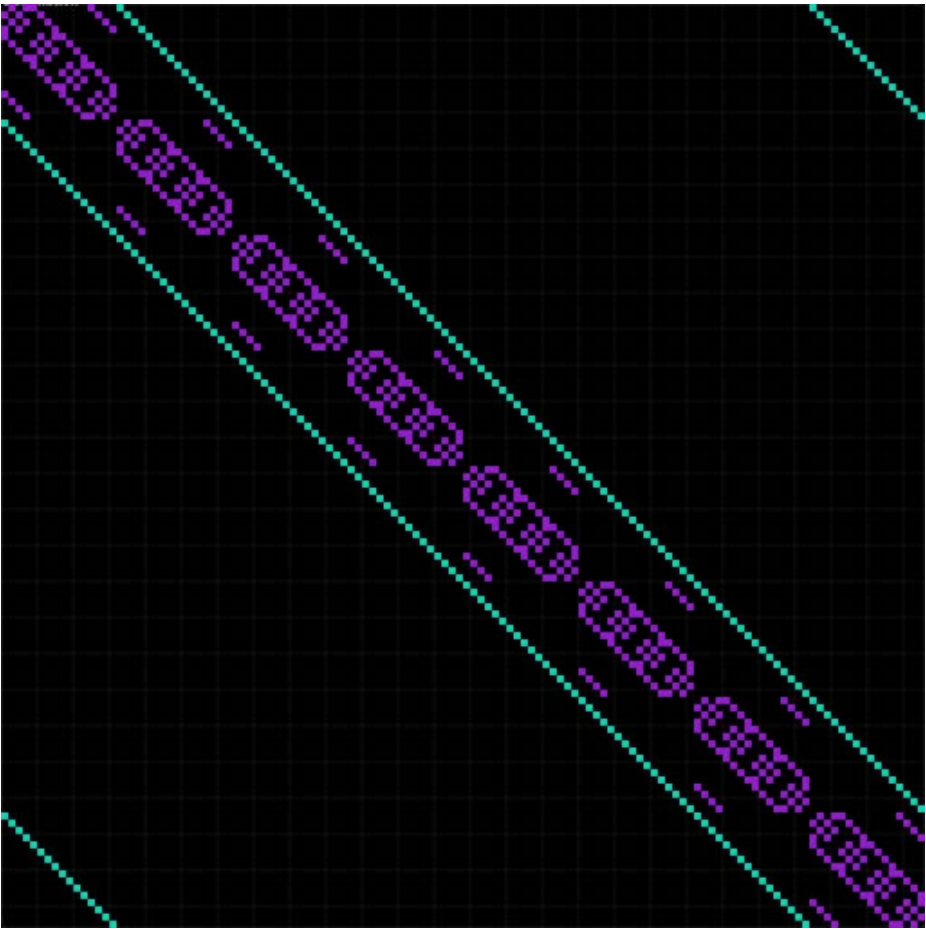


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
SW4/ SW4lite	100	100	100	100	1	1	1	1	1	1

LAMMPS

14414

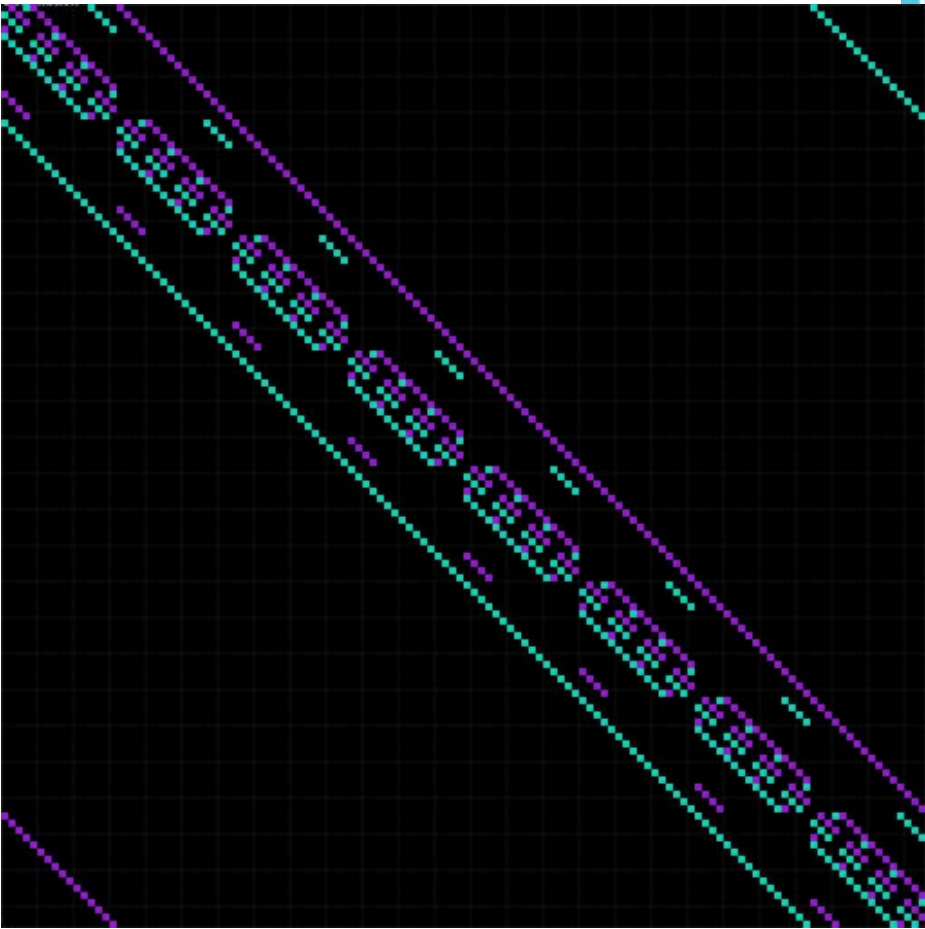
7208



ExaMiniMD

20703

20702

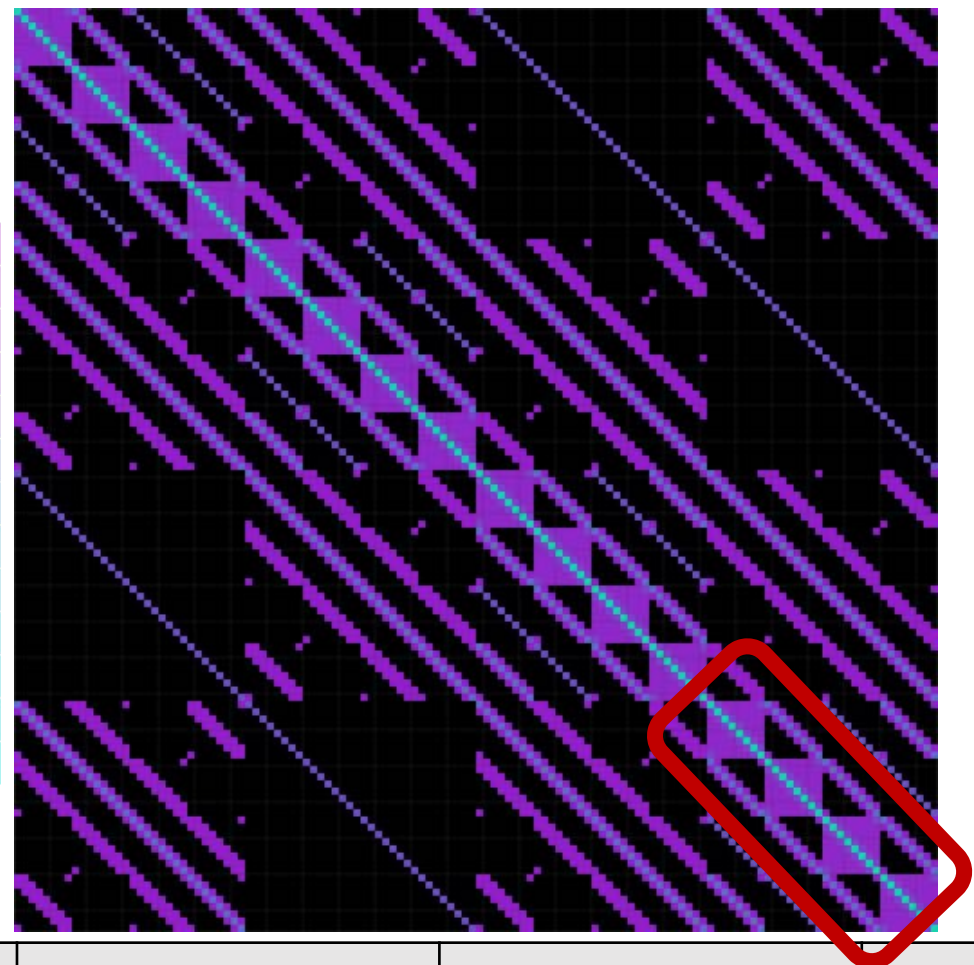


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
LAMMPS/ ExaMMD	100	100	100	100	0	0	0	0	0	0

HACC

1210

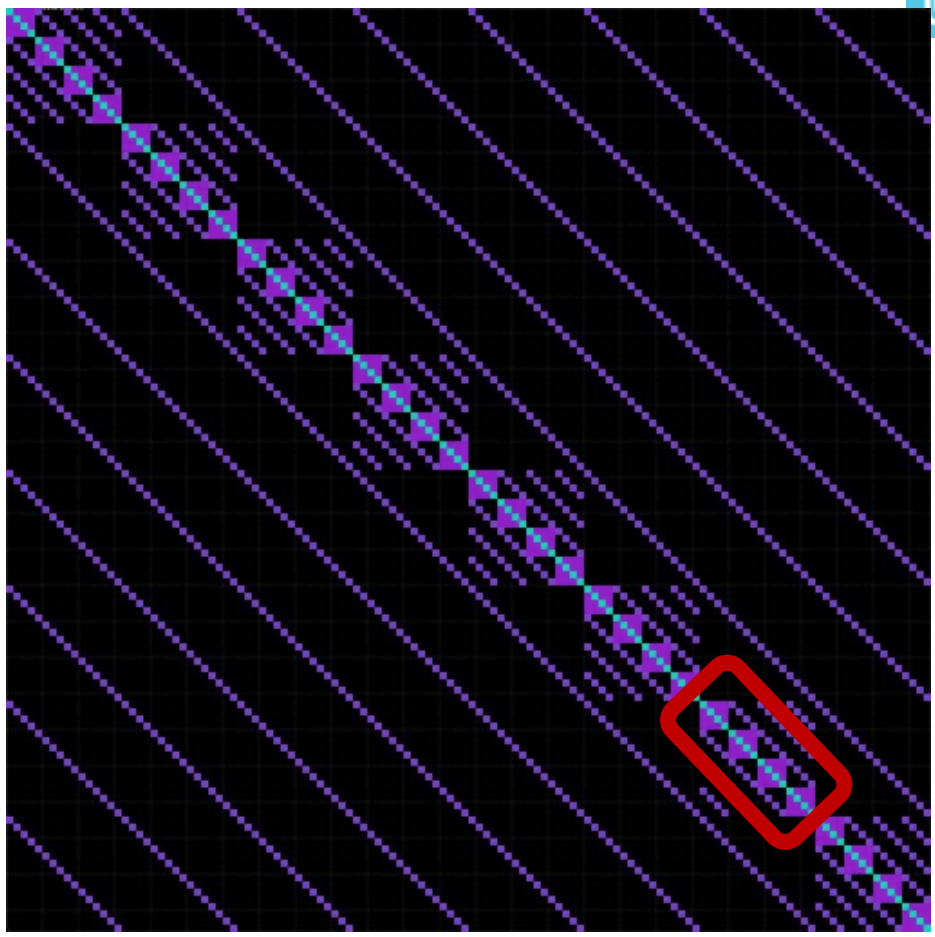
178



SWFFT

500

200

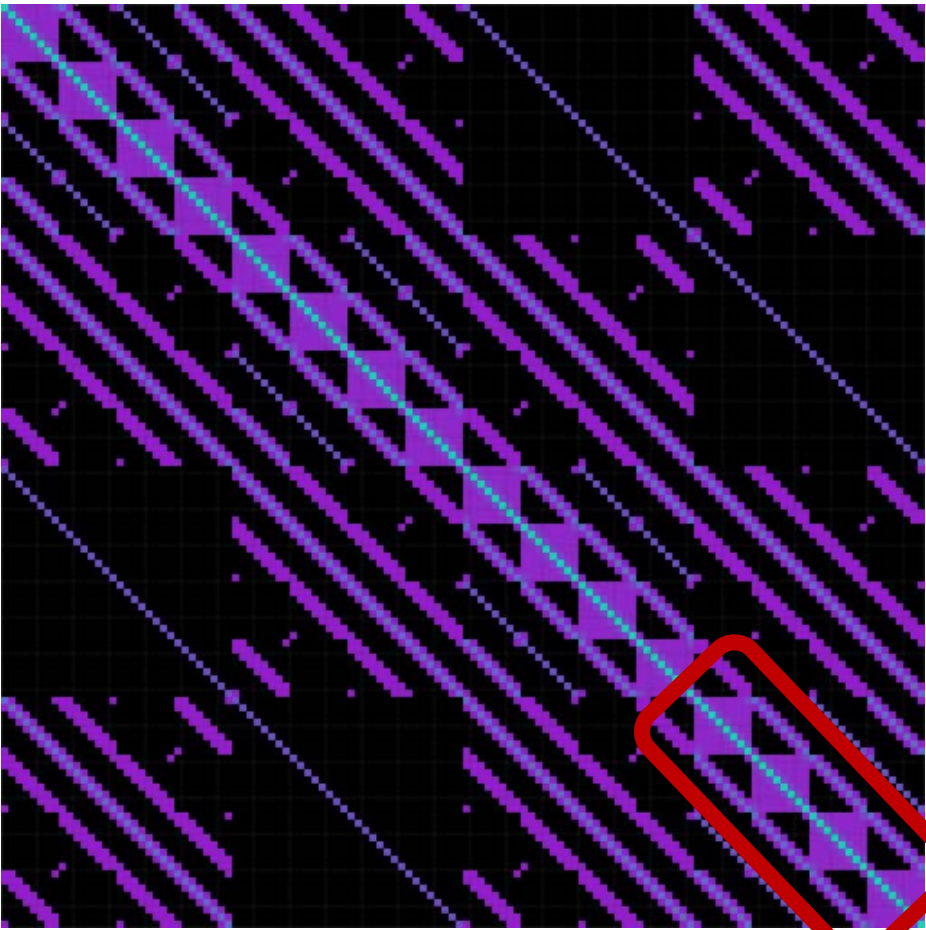


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HACC/ SWFFT	51.7	29.4	71.4	71.4	0.58	0.31	0.61	0.28	0.87	0.81

HACC

1210

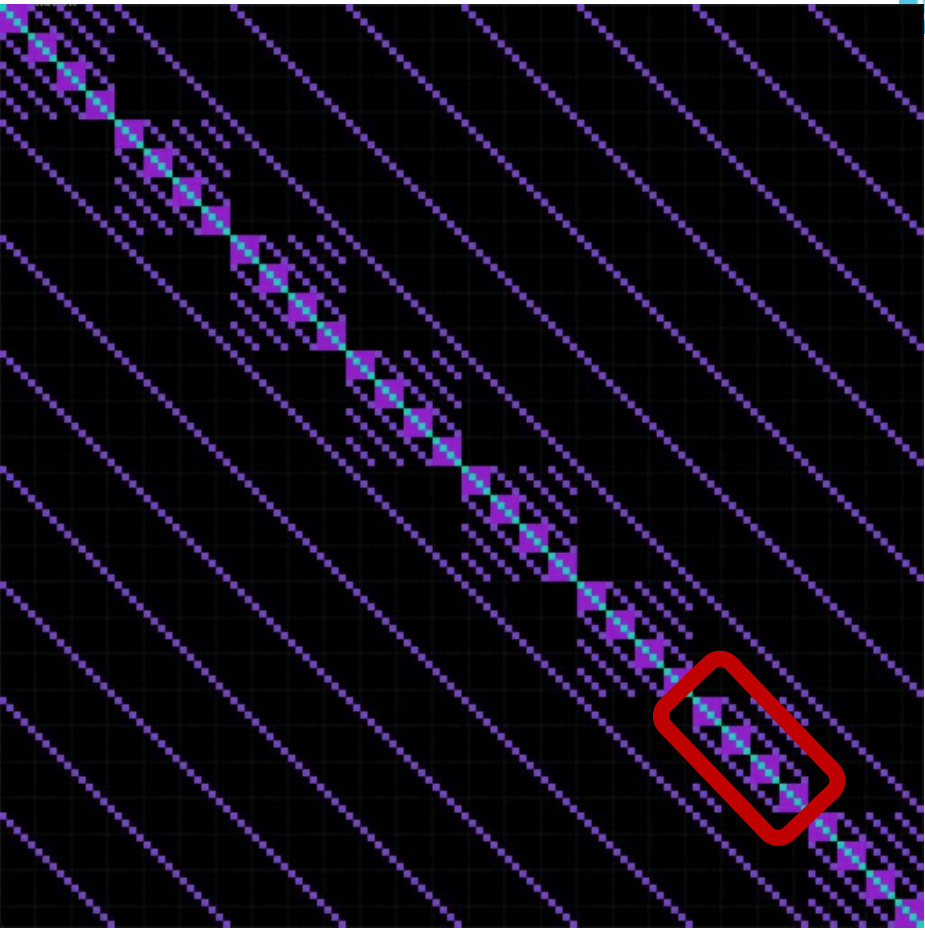
178



SWFFT

500

200

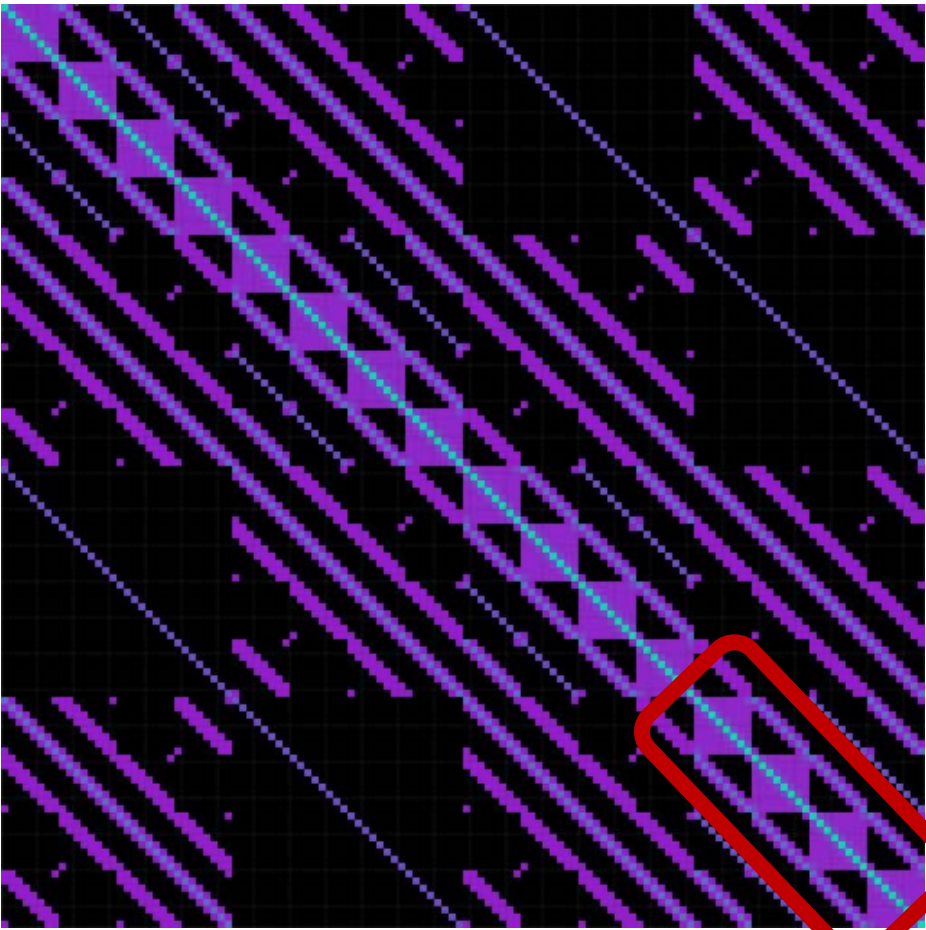


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	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
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HACC

1210

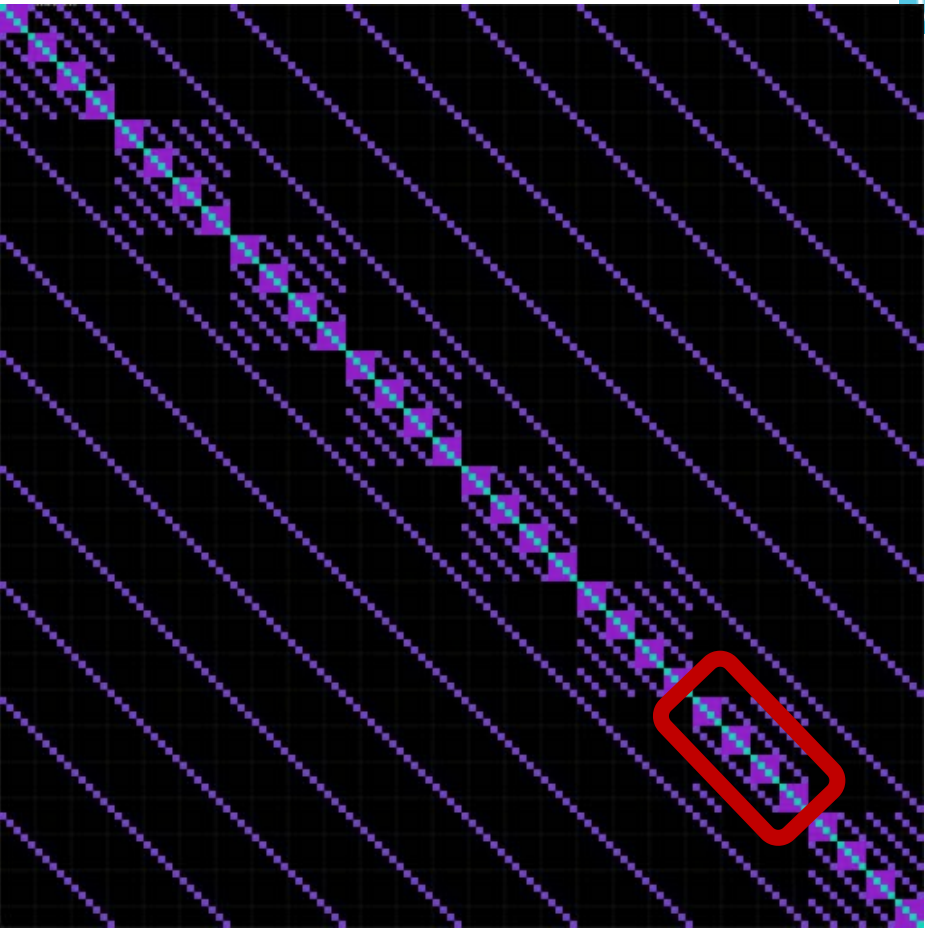
178



SWFFT

500

200

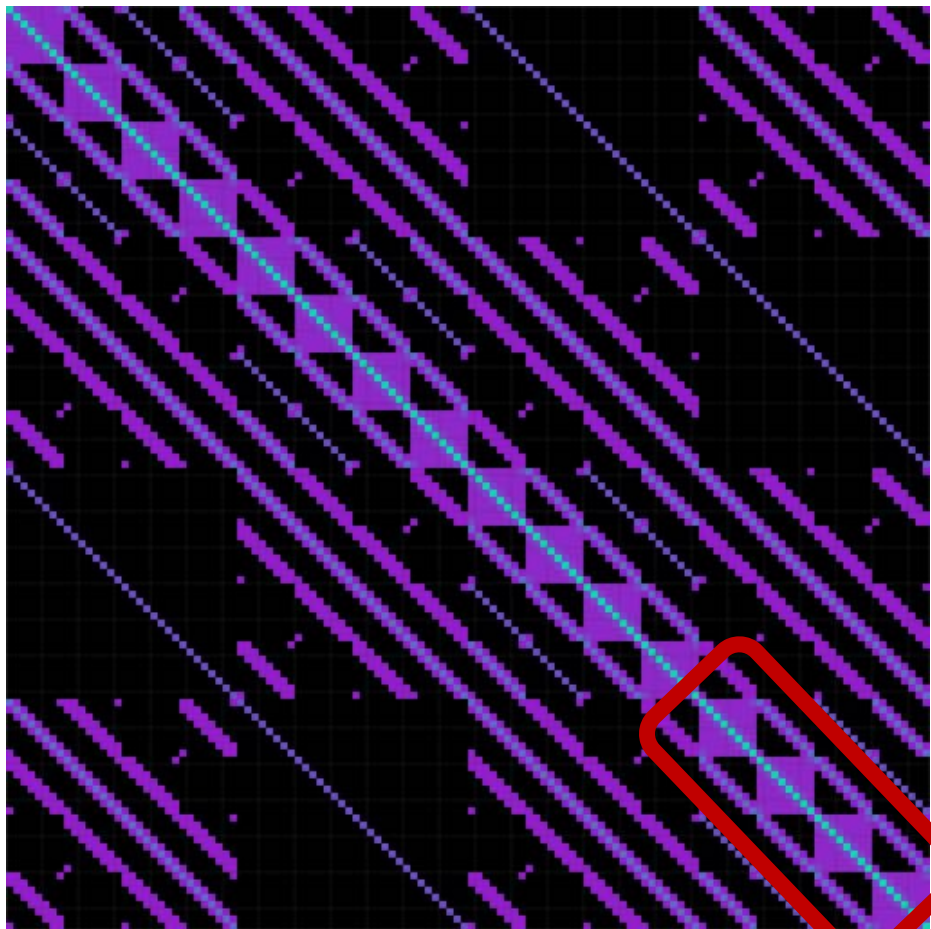


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
HACC/ SWFFT	51.7	29.4	71.4	71.4	0.58	0.31	0.61	0.28	0.87	0.81

HACC

1210

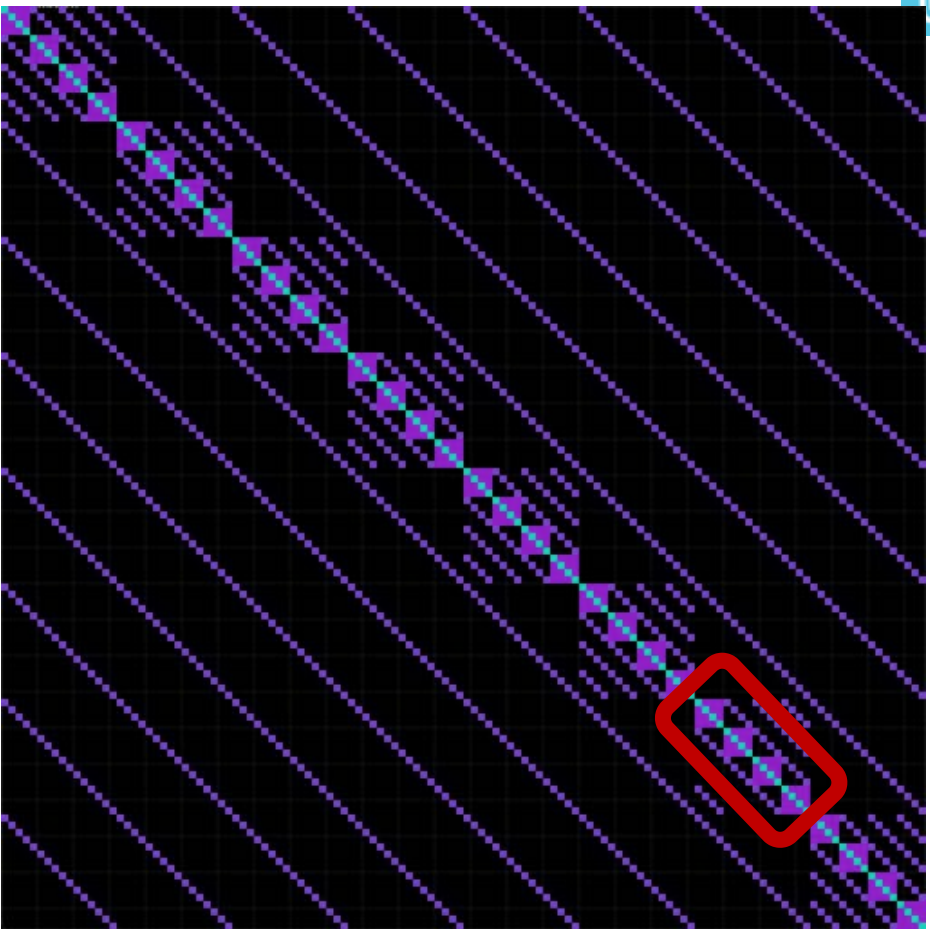
178



SWFFT

500

200

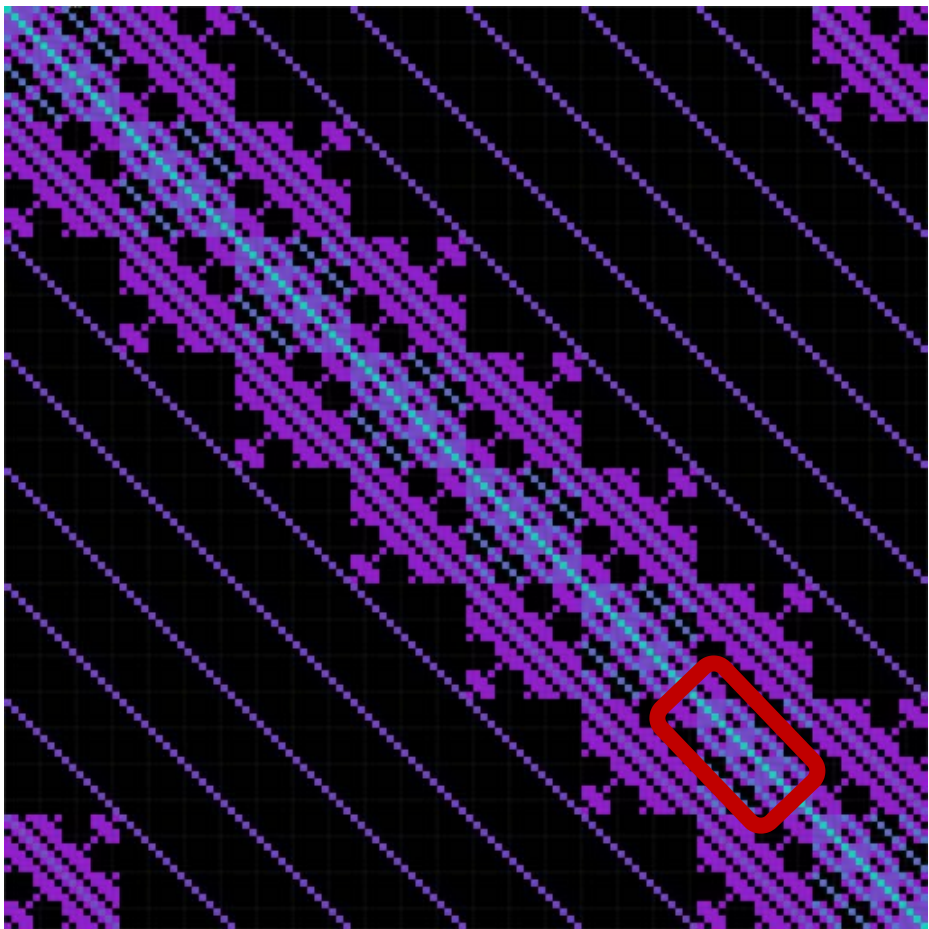


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
HACC/ SWFFT	51.7	29.4	71.4	71.4	0.58	0.31	0.61	0.28	0.87	0.81

HACC

1210

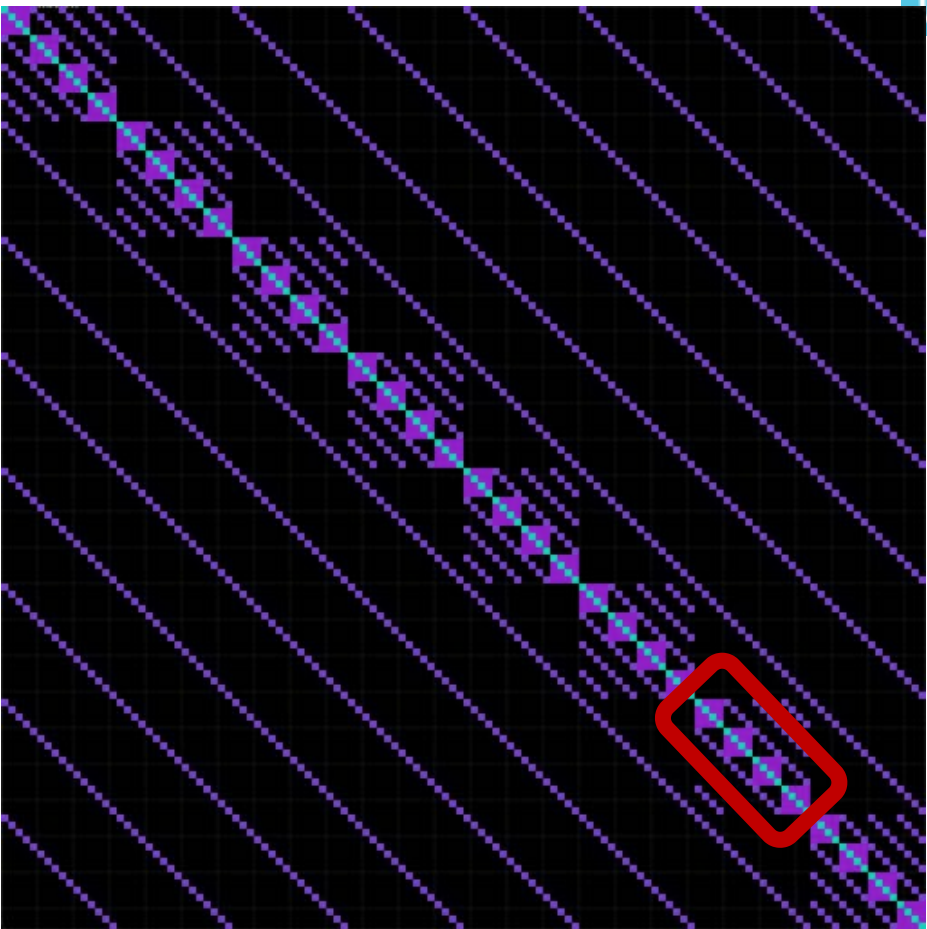
178



SWFFT

500

200

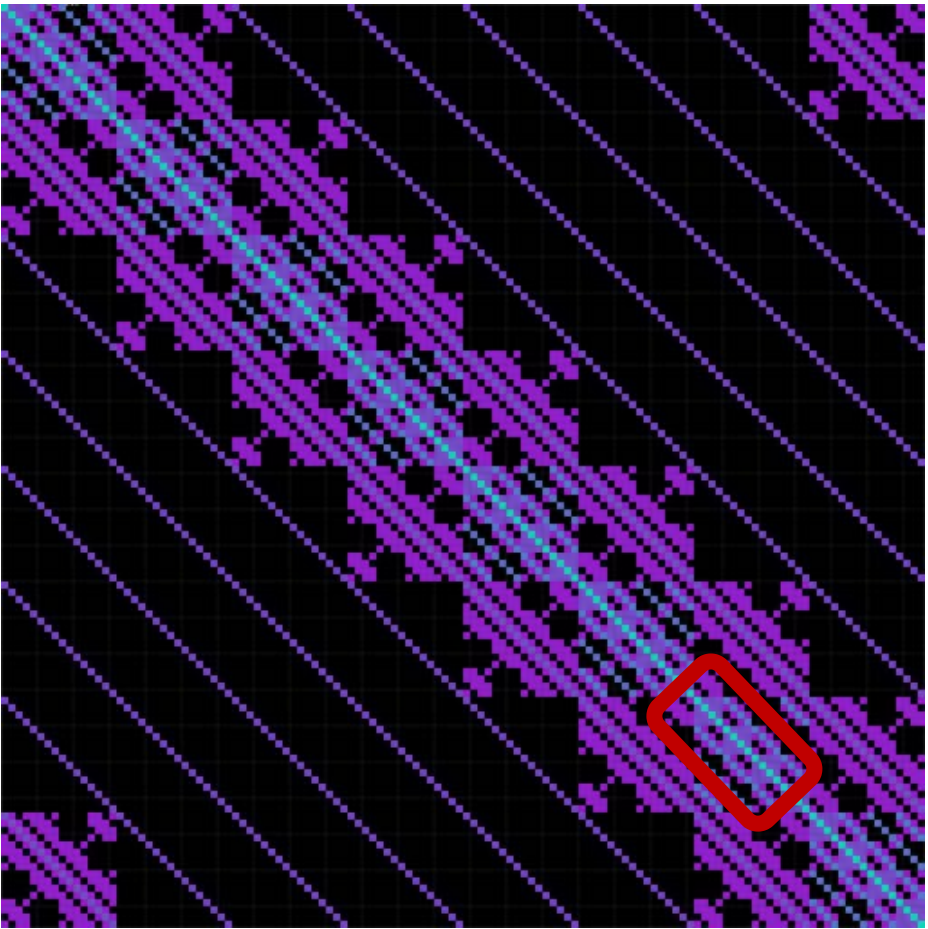


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
HACC/ SWFFT	68.7	41.1	100	100	0.97	0.99	0.92	0.84	0.97	0.99

HACC

1210

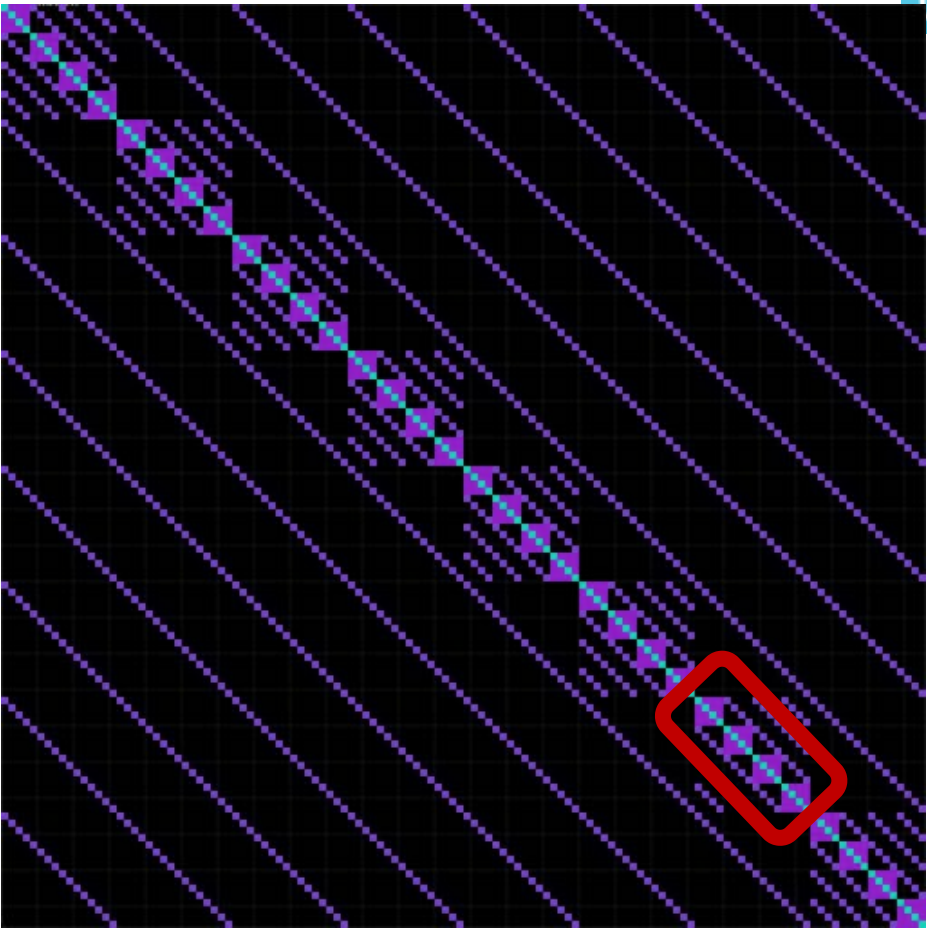
178



SWFFT

500

200

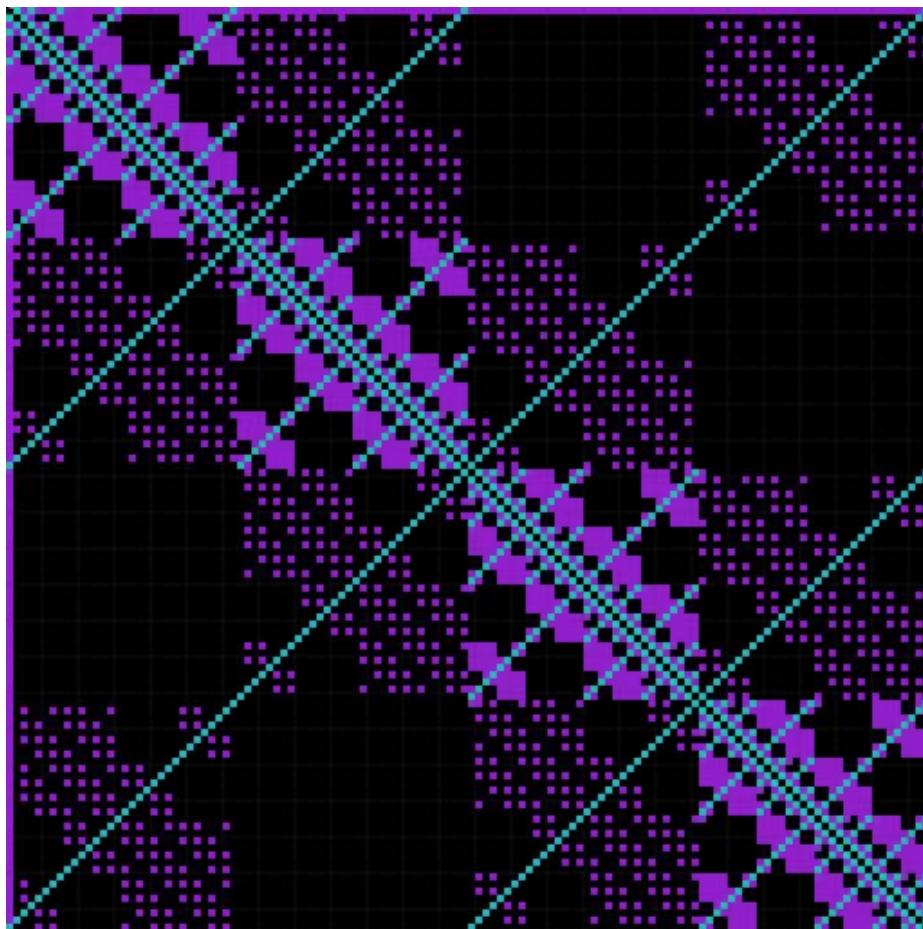


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
HACC/ SWFFT	68.7	41.1	100	100	0.97	0.99	0.92	0.84	0.97	0.99

Nek5K 3D

35046

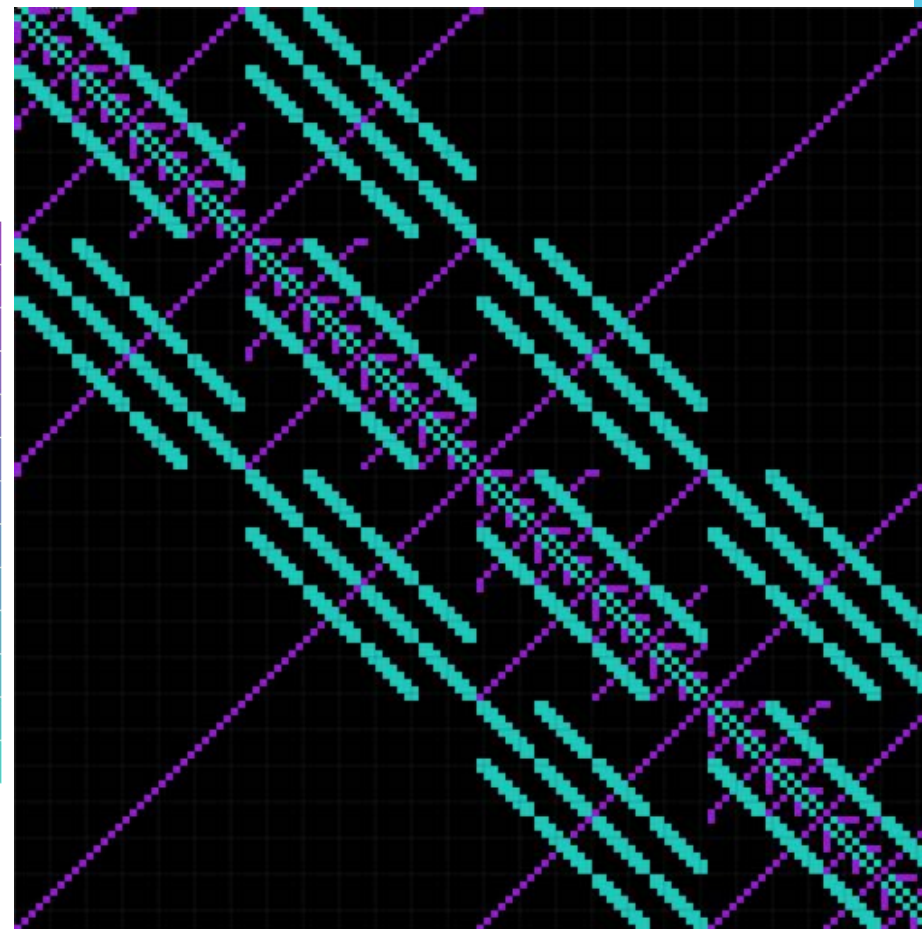
24



Nekbone

15342

651

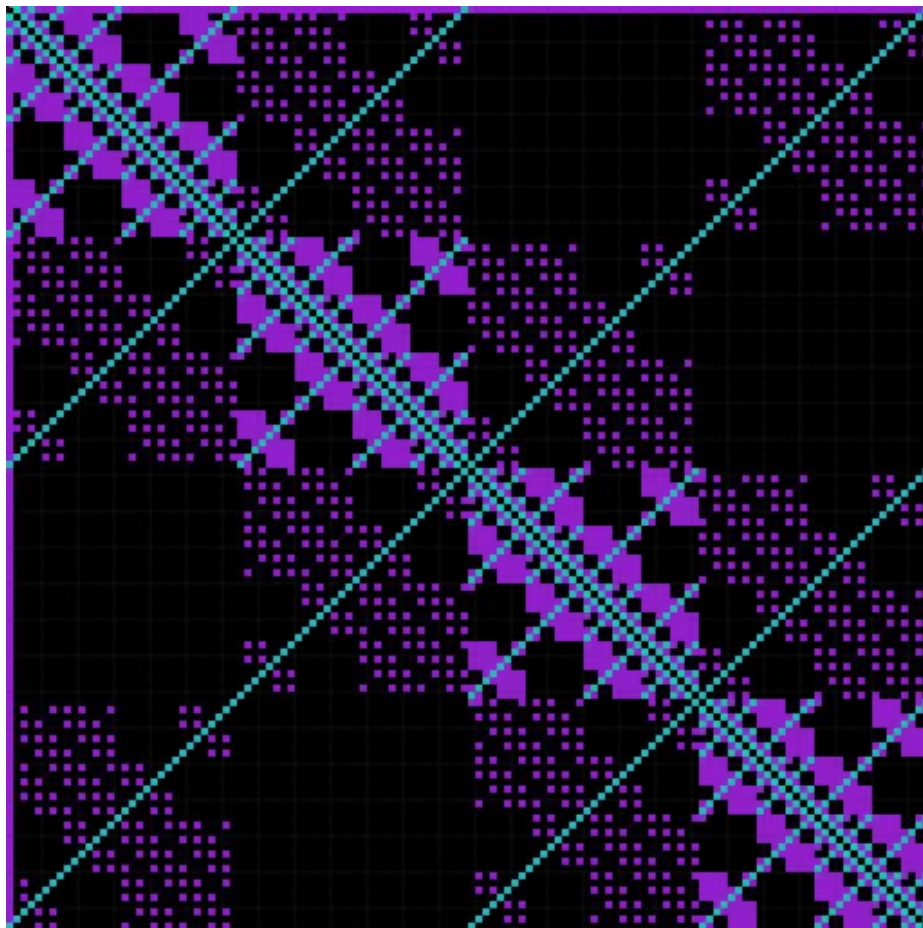


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
Nek5K 3D/ Nekbone 3D	99.9	51.4	58.0	68.4	-0.1	-0.05	-0.65	-0.23	0.04	0.49

Nek5K 3D

35046

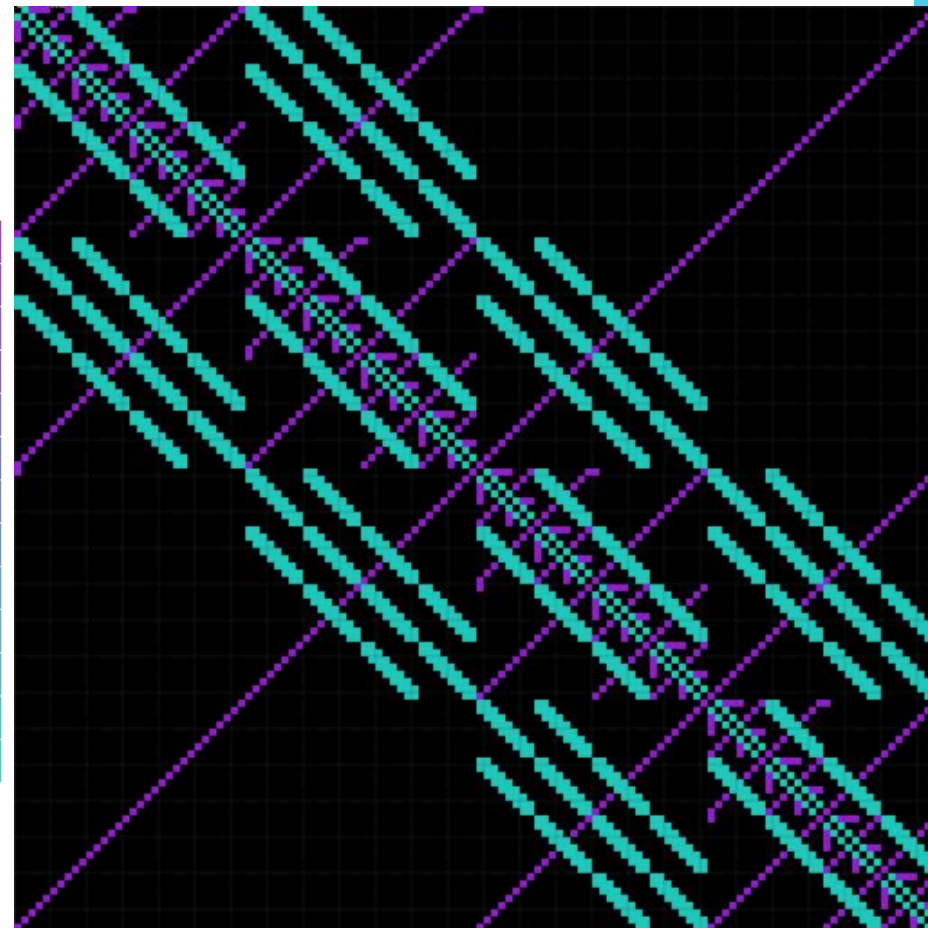
24



Nekbone

15342

651

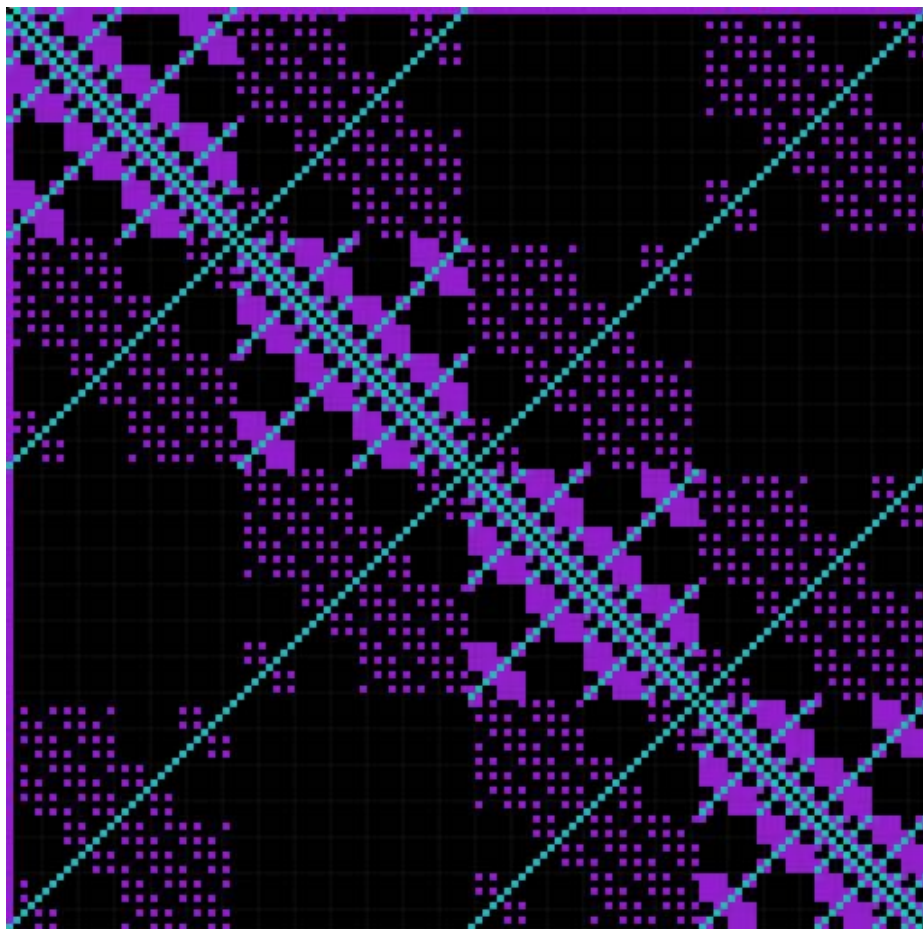


Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
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Nek5K 3D

35046

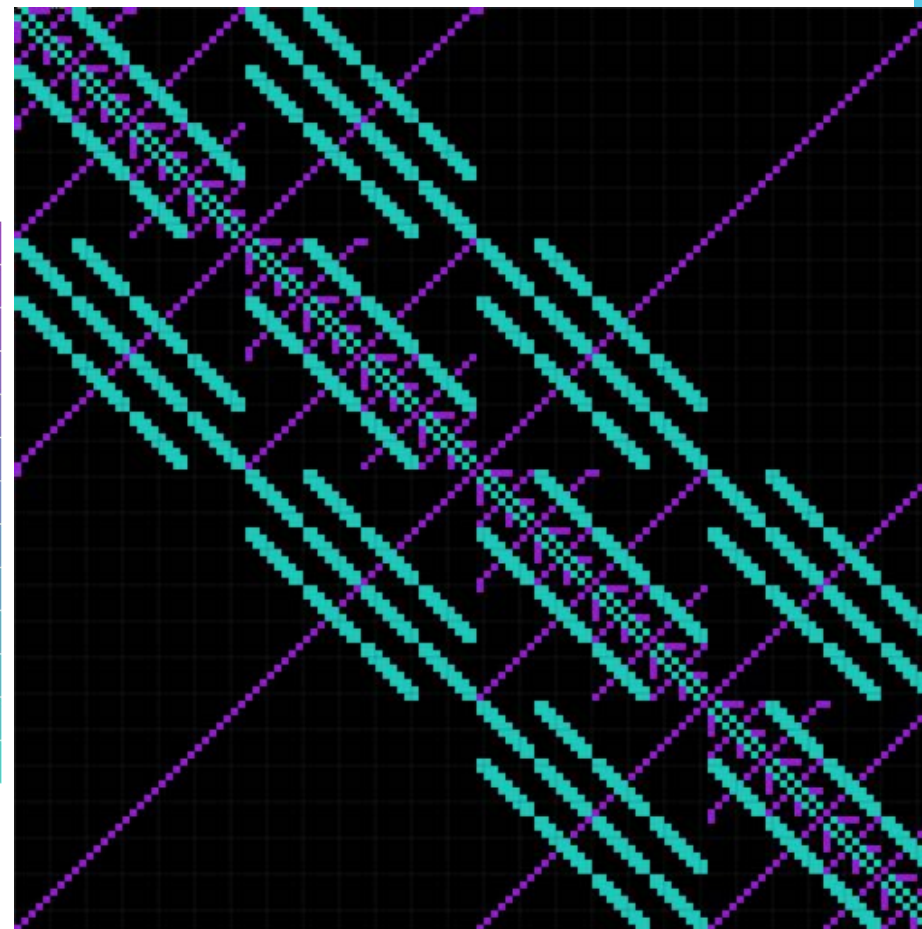
24



Nekbone

15342

651

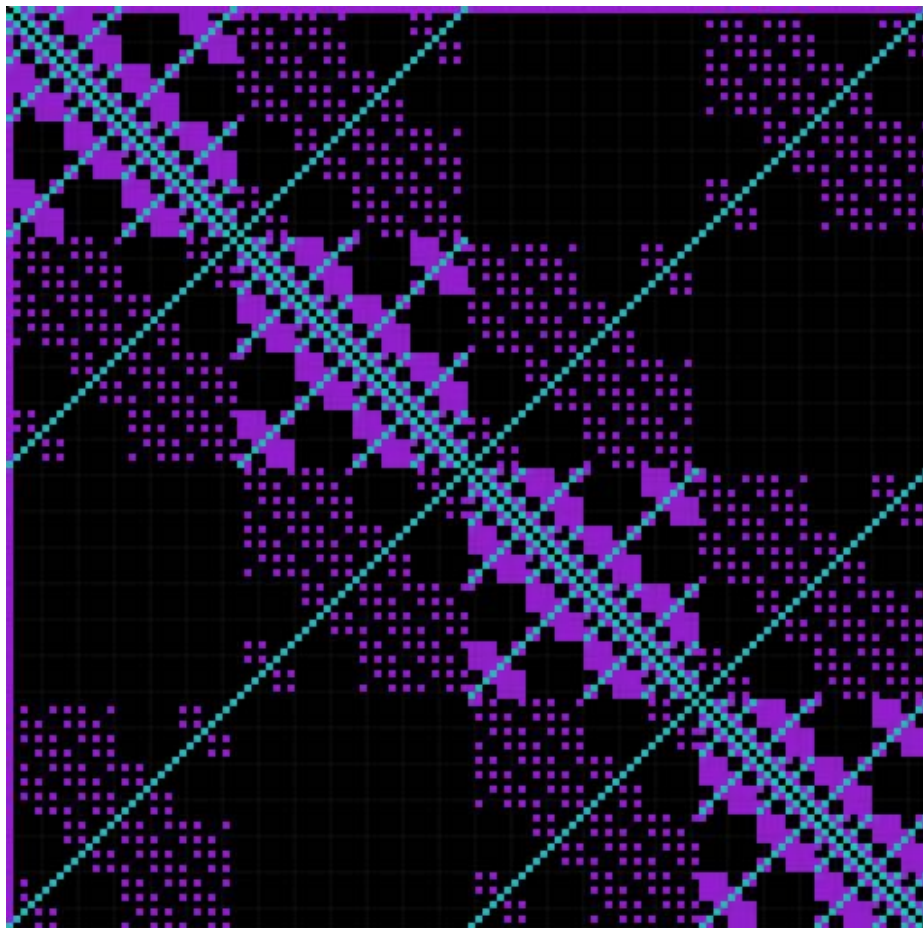


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	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
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Nek5K 3D

35046

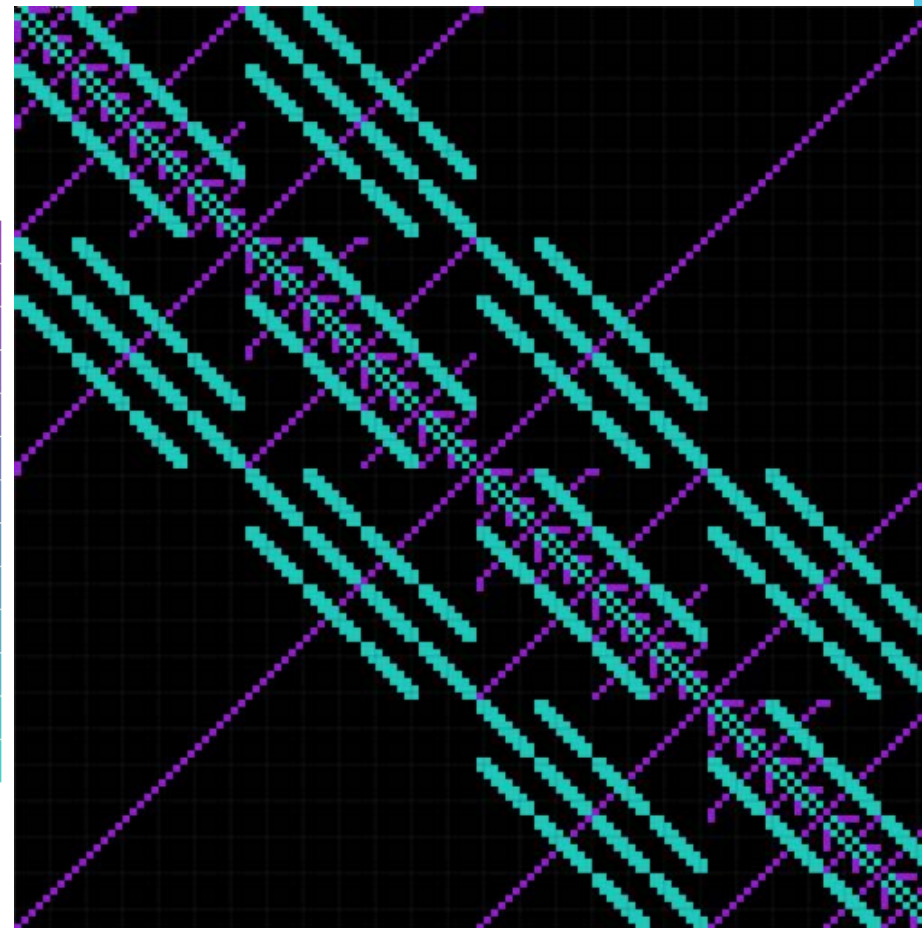
24



Nekbone

15342

651

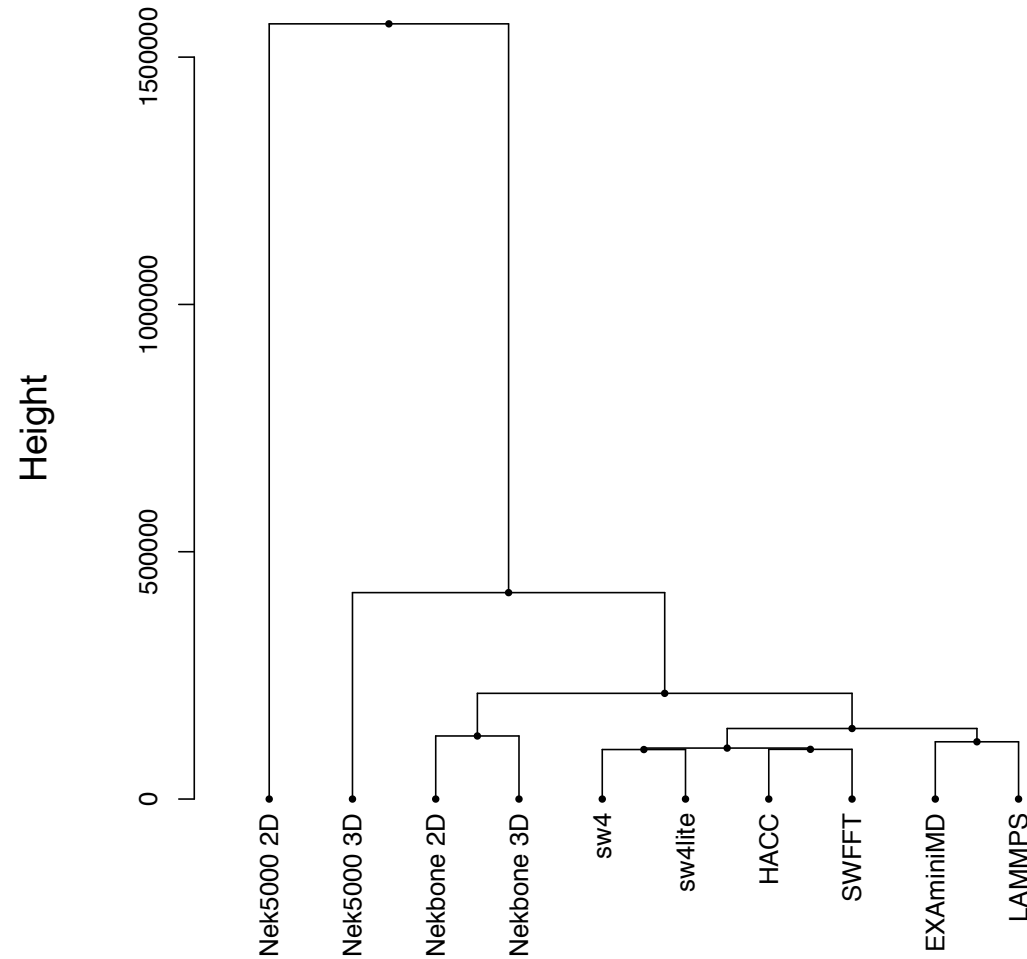


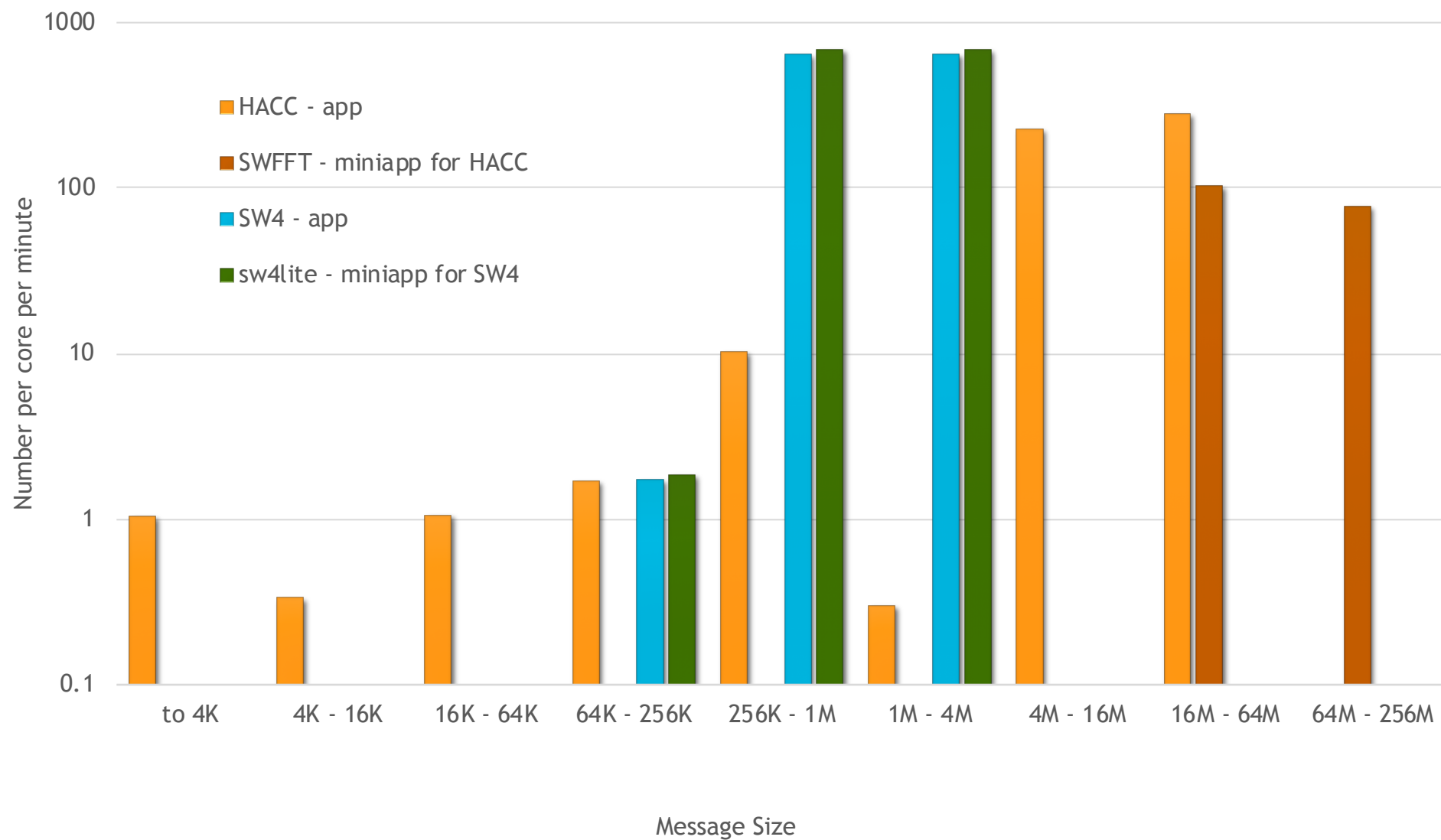
Parent/Proxy	Parent in Proxy		Proxy in Parent		Full Set		Parent in Proxy		Proxy in Parent	
	#msg	#pair	#msg	#pair	PCorr	SCorr	PCorr	SCorr	PCorr	SCorr
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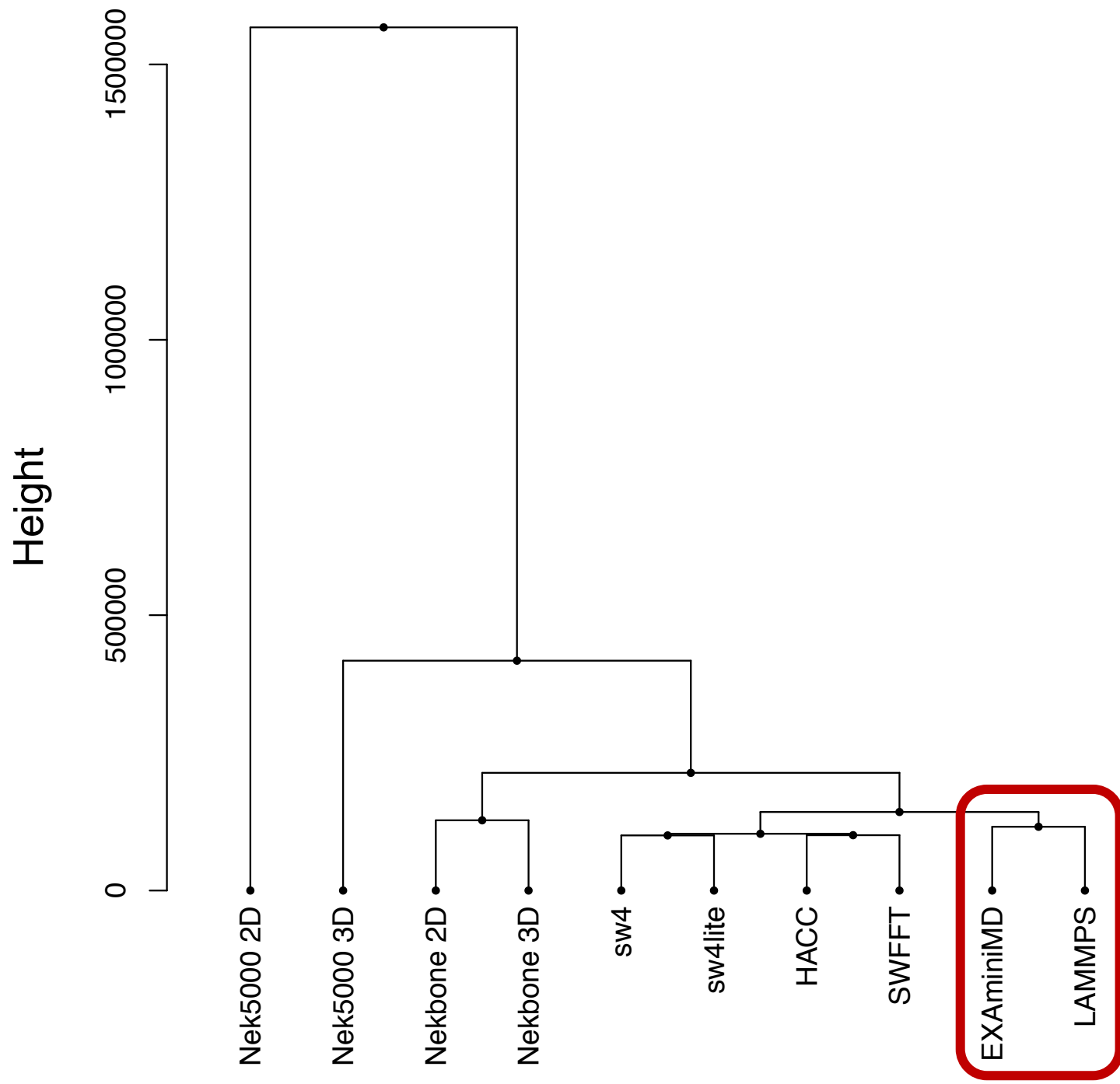


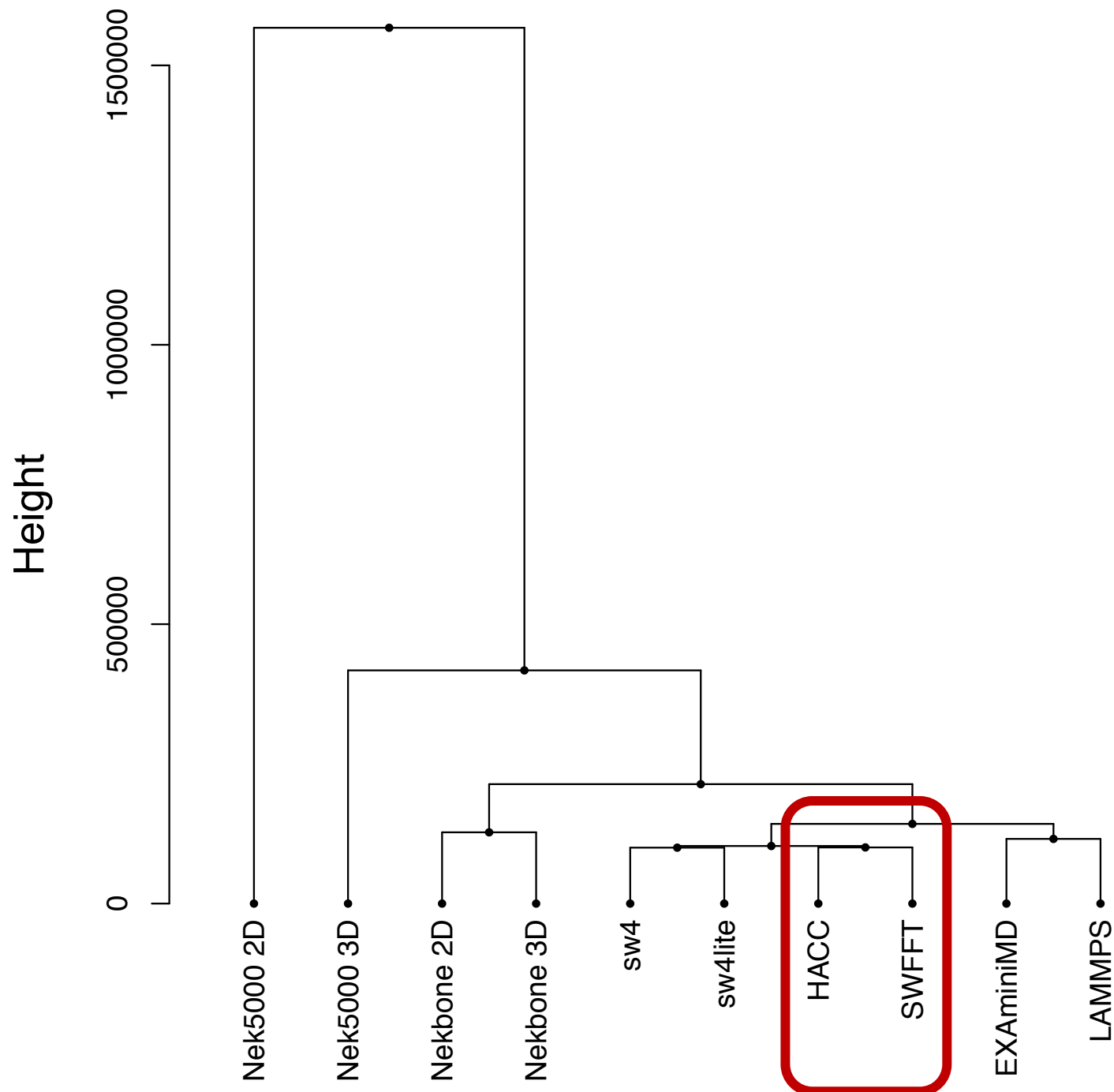
Used vector of data for each proxy and parent application

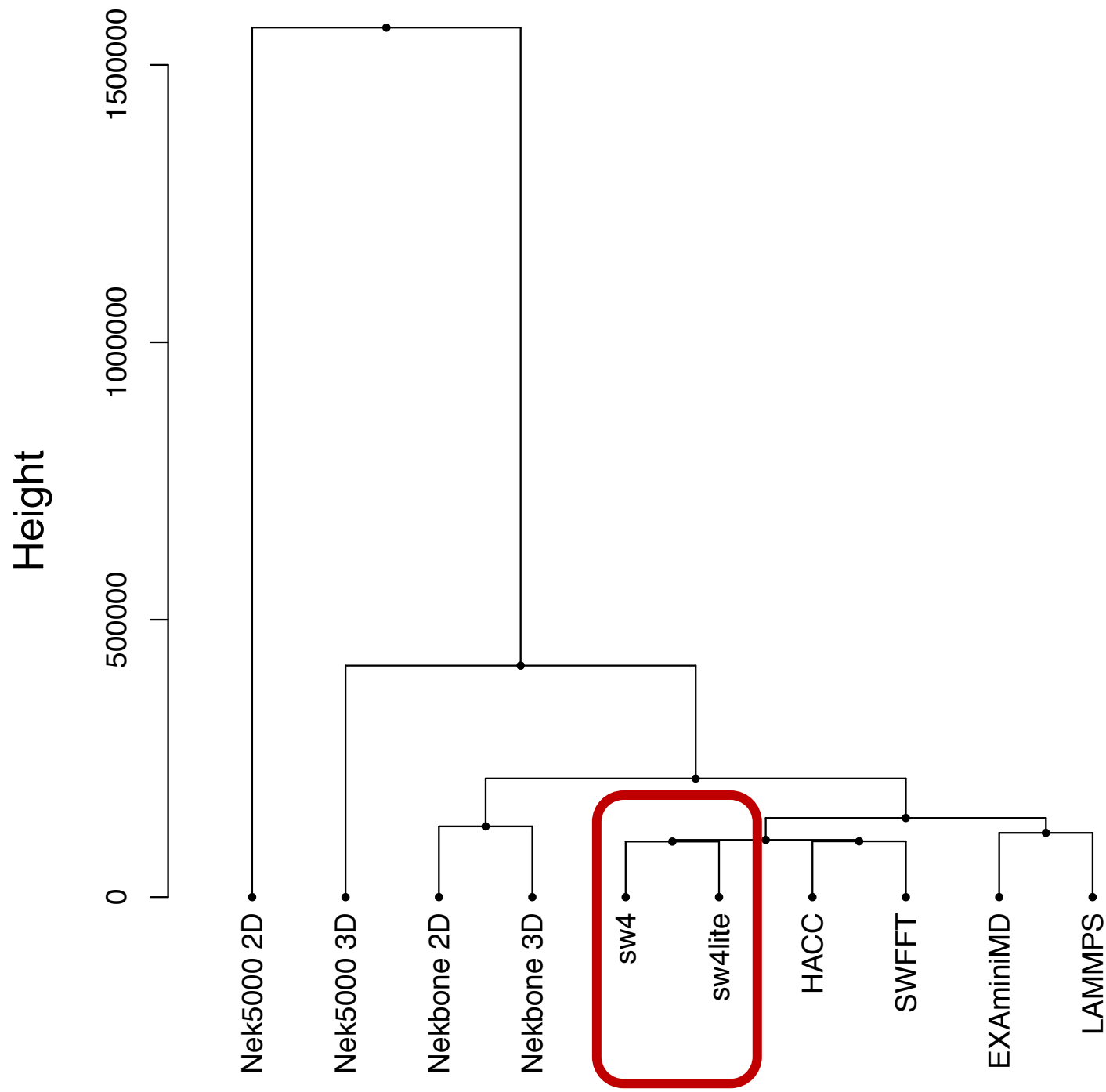
- 10 message size buckets
- 3 summary metrics
- Hierarchical clustering

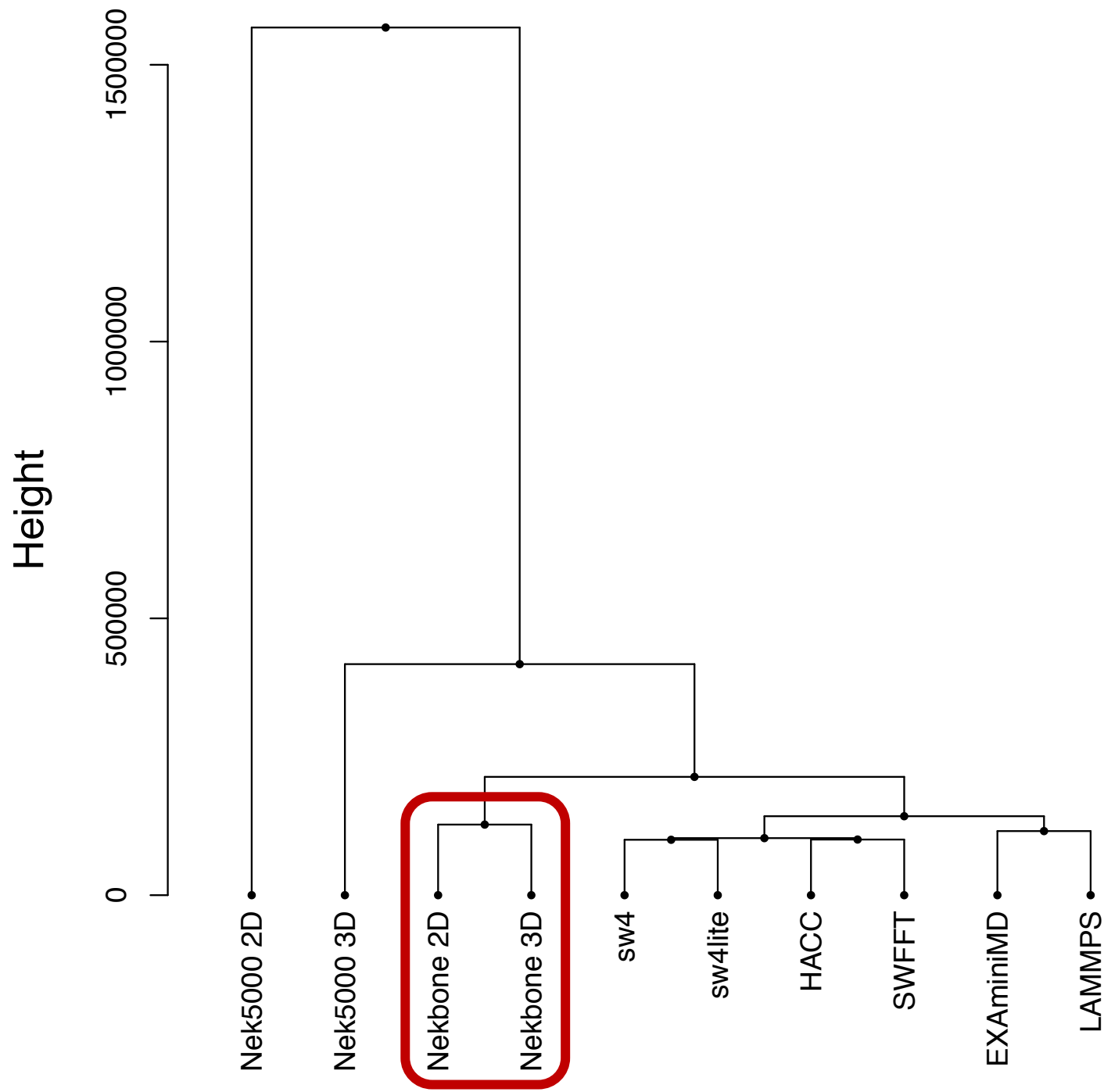


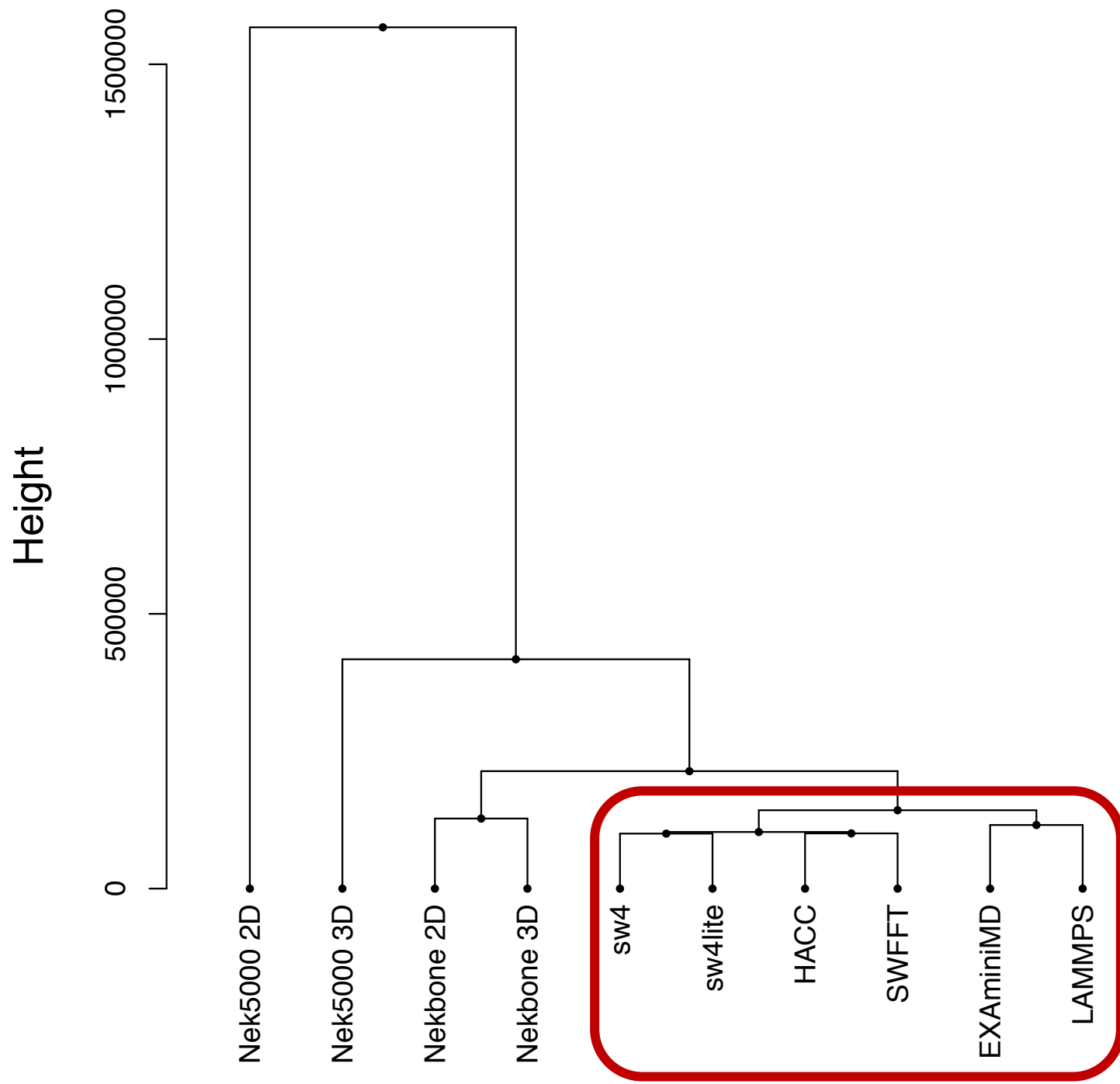


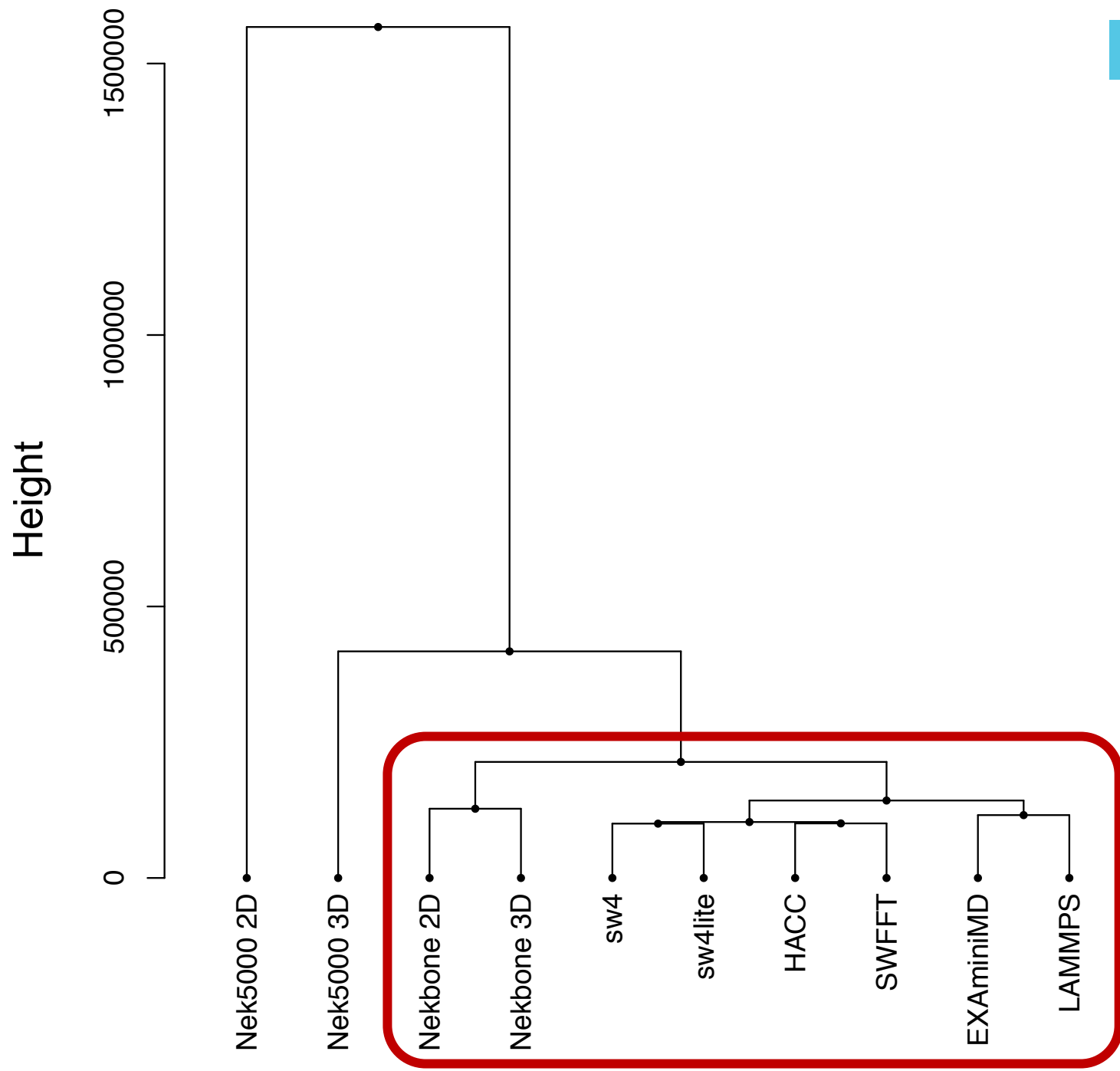


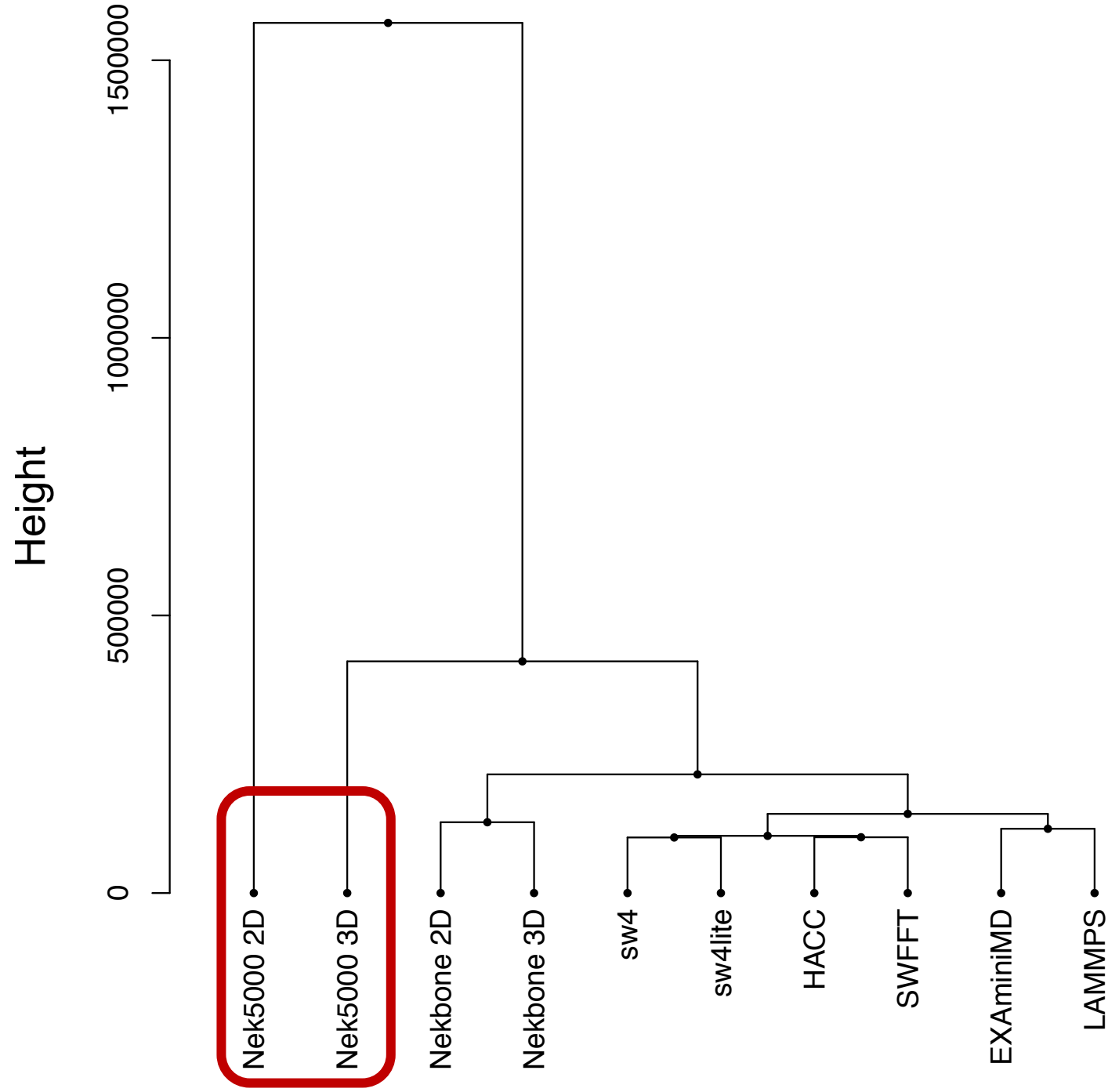














Explored how the communication of a proxy application relates to its parent application

Presented two quantification methods:

- A pairwise communication quantification method that captures how much of one application matches the other
- A message characteristics quantification method that produces a clustering-based relatedness measures of the parent applications and their proxies

Selecting the right input problem is very important

- HACC/SWFFT



We need to understand our current statistics to make better high level conclusions

Examine alternative statistics

Incorporate the work on the communication patterns known as the seven dwarves, and relate both parents and proxies to the dwarf patterns

Explore the relatedness using time-varying behavior

Explore more parent/proxy pairs



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Questions ?
