

Sandbox

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Chapter 1

Sandbox for playing with pandoc/slate

Normal table

Operation	Self	Peer	Host	All
Regular read	448.59	14.01	444.74	12.17
Regular write	442.98	16.21	16.18	12.17
Regular update	248.80	11.71	0.0028	6.00
Random read	6.78	1.43	2.39	4.04
Random write	6.63	1.14	3.47E-5	3.82
Random update	3.44	0.83	1.92E-5	2.08

Pretty wide table

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Modularity optimization	$10(E + V) / p$	20V bytes	$E/p : 2V$	Okay	$88E/p + 12V$ bytes
Graph contraction	$5E / p + E'$	8E' bytes	$5E/p + E' : 8E'$	Hard	16E' bytes
Louvain	$10(E + V) / p$	20V bytes	$E/p : 2V$	Okay	$88E/p + 12V + 16E'$ bytes

Pretty wide table, with math

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Modularity optimization	$10(E + V)/p$	$20V$ bytes	$E/p : 2V$	Okay	$88E/p + 12V$ bytes
Graph contraction	$5E/p + E'$	$8E'$ bytes	$5E/p + E' : 8E'$	Hard	$16E'$ bytes
Louvain	$10(E + V)/p$	$20V$ bytes	$E/p : 2V$	Okay	$88E/p + 12V + 16E'$ bytes

JDO hacked version of above

Parts	Comp cost	Comm cost	Comp/comm ratio	Scalability	Memory usage (B)
Modularity optim.	$10(E + V) / p$	$20V$ bytes	$E/p : 2V$	Okay	$88E/p + 12V$
Graph contraction	$5E / p + E'$	$8E'$ bytes	$5E/p + E' : 8E'$	Hard	$16E'$
Louvain	$10(E + V) / p$	$20V$ bytes	$E/p : 2V$	Okay	$88E/p + 12V + 16E'$

and with math!

Parts	Comp cost	Comm cost	Comp/comm ratio	Scalability	Memory usage (B)
Modularity optim.	$10(E + V)/p$	$20V$ bytes	$E/p : 2V$	Okay	$88E/p + 12V$
Graph contraction	$5E/p + E'$	$8E'$ bytes	$5E/p + E' : 8E'$	Hard	$16E'$
Louvain	$10(E + V)/p$	$20V$ bytes	$E/p : 2V$	Okay	$88E/p + 12V + 16E'$

Even wider table

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Wedge generation	dE/p				

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Wedge communication	0	$aE/p \times 12$ bytes			
Wedge checking	$aE/p \times \log(d)$				
AllReduce	$2V$	$2V \times 4$ bytes			
Triangle Counting	$(d + a \times \log(d))E/p + 2V$	$aE/p \times 12 + 8V$ bytes	$\sim (d + a \times \log(d)) : 12a$	Okay	
Scan Statistics (wedge checks)	$(d + a \times \log(d))E/p + 2V + V/p$	$12aE/p + 8V$ bytes	$\sim (d + a \times \log(d)) : 12a$	Okay	
Scan Statistics (intersection)	$Vdd + V/p$	$8V$ bytes	$dd : 8$	Perfect	

Even wider table, with math!

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Wedge generation	dE/p				
Wedge communication	0	$aE/p \times 12$ bytes			
Wedge checking	$aE/p \times \log(d)$				
AllReduce	$2V$	$2V \times 4$ bytes			
Triangle Counting	$(d + a \times \log(d))E/p + 2V$	$aE/p \times 12 + 8V$ bytes	$(d + a \cdot \log(d)) : 12a$	Okay	
Scan Statistics (wedge checks)	$(d + a \times \log(d))E/p + 2V + V/p$	$12aE/p + 8V$ bytes	$(d + a \cdot \log(d)) : 12a$	Okay	
Scan Statistics (intersection)	$Vdd + V/p$	$8V$ bytes	$dd : 8$	Perfect	

JDO hacked version of above

Parts	Comp. cost	Comm. cost (B)	Comp/comm ratio	Scalability
Wedge generation	dE/p			
Wedge communication	0	$aE/p \times 12$		
Wedge checking	$aE/p \times \log(d)$			
AllReduce	2V	$2V \times 4$		
Triangle Counting	$(d + a \times \log(d))E/p + 2V$	$aE/p \times 12 + 8V$	$\sim(d + a \times \log(d)) : 12a$	Okay
Scan Statistics	$(d + a \times \log(d))E/p + 2V + V/p$	$12aE/p + 8V$	$\sim(d + a \times \log(d)) : 12a$	Okay
(with wedge checks)				
Scan Statistics	$Vdd + V/p$	8V	$dd : 8$	Perfect
(with intersection)				

Table with line breaks

Application	Computation to communication ratio	Scalability	Implementation difficulty
Louvain	$E/p : 2V$	Okay	Hard
Graph SAGE	$\sim CF : \min(C, 2p) \times 4$	Good	Easy
Random walk	Duplicated graph: infinity	Perfect	Trivial
	Distributed graph: $1 : 24$	Very poor	Easy
Graph search: Uniform	$1 : 24$	very poor	Easy
Graph search: Greedy	Straight forward: $d : 24$	Poor very	Easy Easy
	Pre-visit: $1:24$	poor	
Graph search:	Straight forward: $d : 24$	Poor very	Easy Easy
Stochastic greedy	Pre-visit: $\log(d) : 24$	poor	
Geo location	Explicit movement: $25E/p : 4V$	Okay	Easy Easy
	UVM or peer access: $25 : 1$	Good	
Vertex nomination	$E : 8V \times \min(d, p)$	Okay	Easy
Scan statistics	Duplicated graph: infinity	Perfect	Trivial
	Distributed graph: $\sim (d + a * \log(d)) : 12$	Okay	Easy
Sparse fused lasso	$\sim a:8$	Less than okay	Hard
Graph projection	Duplicated graph : infinity	Perfect	Easy Easy
	Distributed graph : $dE/p + E' : 6E'$	Okay	
Local graph clustering	$(6 + d)/p : 4$	Good	Easy

Application	Computation to communication ratio	Scalability	Implementation difficulty
Seeded graph matching			
Application classification			

Table with line breaks, laid out as a grid table

Application	Computation to communication ratio	Scalability	Implementation difficulty
Louvain	$E/p : 2V$	Okay	Hard
Graph SAGE	$\sim CF : \min(C, 2p) \cdot 4$	Good	Easy
Random walk	Duplicated graph: infinity	Perfect	Trivial
	Distributed graph: $1 : 24$	Very poor	Easy
Graph search:	$1 : 24$	Very poor	Easy
Uniform			
Graph search:	Straightforward: $d : 24$	Poor	Easy
Greedy	Pre-visit: $1:24$	Very poor	Easy
Graph search:	Straightforward: $d : 24$	Poor	Easy
Stochastic greedy	Pre-visit: $\log(d) : 24$	Very poor	Easy
Geolocation	Explicit movement:	Okay	Easy
	$25E/p : 4V$	Good	Easy
	UVM or peer access: $25 : 1$		
Vertex nomination	$E : 8V \cdot \min(d, p)$	Okay	Easy
Scan statistics	Duplicated graph: infinity	Perfect	Trivial
	Distributed graph:	Okay	Easy
	$\sim (d + a \cdot \log(d)) : 12$		
Sparse fused lasso	$\sim a : 8$	Less than okay	Hard
Graph projection	Duplicated graph : infinity	Perfect	Easy
	Distributed graph :	Okay	Easy
	$dE/p + E' : 6E'$		
Local graph clustering	$(6 + d)/p : 4$	Good	Easy
Seeded graph matching			
Application classification			

JDO hacked version of above

Application	Computation to communication ratio	Scalability	Implementation diff.
Louvain	E/p : 2V	Okay	Hard
Graph SAGE	$\sim CF : \min(C, 2p) \times 4$	Good	Easy
Random walk	Duplicated graph: infinity	Perfect	Trivial
Random walk	Distrib. graph: 1 : 24	Very poor	Easy
Graph search: Uniform	1 : 24	Very poor	Easy
Graph search: Greedy	Straightforward: d : 24	Poor	Easy
Graph search: Greedy	Pre-visit: 1:24	Very poor	Easy
G.S.: Stochastic greedy	Straightforward: d : 24	Poor	Easy
G.S.: Stochastic greedy	Pre-visit: $\log(d) : 24$	Very poor	Easy
Geolocation	Explicit movement: $25E/p : 4V$	Okay	Easy
Geolocation	UVM or peer access: 25 : 1	Good	Easy
Vertex nomination	E : $8V \times \min(d, p)$	Okay	Easy
Scan statistics	Duplicated graph: infinity	Perfect	Trivial
Scan statistics	Distrib. graph: $\sim (d + a * \log(d)) : 12$	Okay	Easy
Sparse fused lasso	$\sim a:8$	Less than okay	Hard
Graph projection	Duplicated graph : infinity	Perfect	Easy
Graph projection	Distrib. graph : $dE/p + E' : 6E'$	Okay	Easy
Local graph clustering	$(6 + d)/p : 4$	Good	Easy

Really wide table

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
<i>Feature duplication</i>					
Children selection	BC	8BC bytes	1 : 8	Poor	
Child-centric comp.	BCF x (2 + L + Wf1.y + Wa1.y)	4B x (F + Wf1.y + Wa1.y) x $\min(C, 2p)$ bytes	$\sim CF : \min(C, 2p) \times 4$	Good	

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Source-centric comp.	$B \times (CF + (Wf1.y + Wa1.y) \times (C + F + Wf2.y + Wa2.y))$	0 bytes	N.A.	N.A.	
Graph SAGE	$B \times (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \times (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p)$ bytes	at least $\sim CF : \min(C, 2p) \times 4$	Good	
<i>Direct feature access</i>					
Child-centric comp.	$BCF \times (2 + L + Wf1.y + Wa1.y)$	$4B \times ((F + Wf1.y + Wa1.y) \times \min(C, 2p) + CLF)$ bytes	$\sim (2 + L + Wf1.y + Wa1.y) : 4L$	poor	
Graph SAGE	$B \times (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \times (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p) + 4BCFL$ bytes	$\sim (2 + L + Wf1.y + Wa1.y) : 4L$	poor	
<i>Feature in UVM</i>					

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Child-centric comp.	$BCF \times (2 + L + Wf1.y + Wa1.y)$	$4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p)$ bytes over GPU-GPU + $4BCLF$ bytes over GPU-CPU	$\sim (2 + L + Wf1.y + Wa1.y) : 4L$ over GPU-CPU	very poor	
Graph SAGE	$B \times (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \times (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p)$ bytes over GPU-GPU + $4BCFL$ bytes over GPU-CPU	$\sim (2 + L + Wf1.y + Wa1.y) : 4L$ over GPU-CPU	very poor	

Really wide table, with math

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
<i>Feature duplication</i>					
Children selection	BC	$8BC$ bytes	$1 : 8$	Poor	
Child-centric comp.	$BCF \cdot (2 + L + Wf1.y + Wa1.y)$	$4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$ bytes	$CF : \min(C, 2p) \cdot 4$	Good	
Source-centric comp.	$B \cdot (CF + (Wf1.y + Wa1.y) \cdot (C + F + Wf2.y + Wa2.y))$	0 bytes	N.A.	N.A.	

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Graph SAGE	$B \cdot (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \cdot (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$ bytes	at least $CF : \min(C, 2p) \cdot 4$	Good	
<i>Direct feature access</i>					
Child-centric comp.	$BCF \cdot (2 + L + Wf1.y + Wa1.y)$	$4B \cdot ((F + Wf1.y + Wa1.y) \cdot \min(C, 2p) + CLF)$ bytes	$(2 + L + Wf1.y + Wa1.y) : 4L$	poor	
Graph SAGE	$B \cdot (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \cdot (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p) + 4BCFL$ bytes	$(2 + L + Wf1.y + Wa1.y) : 4L$	poor	
<i>Feature in UVM</i>					
Child-centric comp.	$BCF \cdot (2 + L + Wf1.y + Wa1.y)$	$4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$ bytes over GPU-GPU + $4BCLF$ bytes over GPU-CPU	$(2 + L + Wf1.y + Wa1.y) : 4L$ over GPU-CPU	very poor	

Parts	Comp. cost	Comm. cost	Comp. to comm. ratio	Scalability	Memory usage
Graph SAGE	$B \cdot (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \cdot (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$ bytes over GPU-GPU	$(2+L+Wf1.y+ Wa1.y) : 4L$ over GPU-CPU	very poor	

Really wide table, with math, nicely laid out

Parts	Computation cost	Communication cost (Bytes)	Comp. to comm. ratio	Scalability
<i>Feature duplication</i>				
Children selection	BC	$8BC$	$1 : 8$	Poor
Child-centric comp.	$BCF \cdot (2 + L + Wf1.y + Wa1.y)$	$4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$	$CF : \min(C, 2p) \cdot 4$	Good
Source-centric comp.	$B \cdot (CF + (Wf1.y + Wa1.y) \cdot (C + F + Wf2.y + Wa2.y))$	0	N.A.	N.A.
Graph SAGE	$B \cdot (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \cdot (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$	at least $CF : \min(C, 2p) \cdot 4$	Good
<i>Direct feature access</i>				
Child-centric comp.	$BCF \cdot (2 + L + Wf1.y + Wa1.y)$	$4B \cdot ((F + Wf1.y + Wa1.y) \cdot \min(C, 2p) + CLF)$	$(2 + L + Wf1.y + Wa1.y) : 4L$	poor

Parts	Computation cost	Communication cost (Bytes)	Comp. to comm. ratio	Scalability
Graph SAGE	$B \cdot (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \cdot (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p) + 4BCFL$	$(2 + L + Wf1.y + Wa1.y) : 4L$	poor
<i>Feature in UVM</i>				
Child-centric comp.	$BCF \cdot (2 + L + Wf1.y + Wa1.y)$	$4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$ bytes over GPU-GPU + $4BCFL$ bytes over GPU-CPU	$(2 + L + Wf1.y + Wa1.y) : 4L$ over GPU-CPU	very poor
Graph SAGE	$B \cdot (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \cdot (CF + C + F + Wf2.y + Wa2.y))$	$8BC + 4B \cdot (F + Wf1.y + Wa1.y) \cdot \min(C, 2p)$ bytes over GPU-GPU + $4BCFL$ bytes over GPU-CPU	$(2 + L + Wf1.y + Wa1.y) : 4L$ over GPU-CPU	very poor

JDO hacked version of above

Parts	Comp. cost
<i>Feature duplication</i>	
Children selection	BC
Child-centric comp.	$BCF \times (2 + L + Wf1.y + Wa1.y)$
Source-centric comp.	$B \times (CF + (Wf1.y + Wa1.y) \times (C + F + Wf2.y + Wa2.y))$
Graph SAGE	$B \times (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \times (CF + C + F + Wf2.y + Wa2.y))$
<i>Direct feature access</i>	
Child-centric comp.	$BCF \times (2 + L + Wf1.y + Wa1.y)$

Parts	Comp. cost
Graph SAGE	$B \times (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \times (CF + C + F + Wf2.y + Wa2.y))$
<i>Feature in UVM</i>	
Child-centric comp.	$BCF \times (2 + L + Wf1.y + Wa1.y)$
Graph SAGE	$B \times (C + 3CF + 3LCF + (Wf1.y + Wa1.y) \times (CF + C + F + Wf2.y + Wa2.y))$

Parts	Comm. cost
<i>Feature duplication</i>	
Children selection	8BC bytes
Child-centric comp.	$4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p)$ bytes
Source-centric comp.	0 bytes
Graph SAGE	$8BC + 4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p)$ bytes
<i>Direct feature access</i>	
Child-centric comp.	$4B \times ((F + Wf1.y + Wa1.y) \times \min(C, 2p) + CLF)$ bytes
Graph SAGE	$8BC + 4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p) + 4BCFL$ bytes
<i>Feature in UVM</i>	
Child-centric comp.	$4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p)$ bytes over GPU-GPU
Graph SAGE	$8BC + 4B \times (F + Wf1.y + Wa1.y) \times \min(C, 2p)$ bytes over GPU-GPU + 4BCFL bytes over GPU-CPU

Parts	Comp/comm ratio	Scalability
<i>Feature duplication</i>		

Parts	Comp/comm ratio	Scalability
Children selection	1 : 8	Poor
Child-centric comp.	$\sim \text{CF} : \min(\text{C}, 2\text{p}) \times 4$	Good
Source-centric comp.	N.A.	N.A.
Graph SAGE	at least $\sim \text{CF} : \min(\text{C}, 2\text{p}) \times 4$	Good
<i>Direct feature access</i>		
Child-centric comp.	$\sim (2 + \text{L} + \text{Wf1.y} + \text{Wa1.y}) : 4\text{L}$	poor
Graph SAGE	$\sim (2 + \text{L} + \text{Wf1.y} + \text{Wa1.y}) : 4\text{L}$	poor
<i>Feature in UVM</i>		
Child-centric comp.	$\sim (2 + \text{L} + \text{Wf1.y} + \text{Wa1.y}) : 4\text{L}$ over GPU-CPU	very poor
Graph SAGE	$\sim (2 + \text{L} + \text{Wf1.y} + \text{Wa1.y}) : 4\text{L}$ over GPU-CPU	very poor

Let's try a grid table with backslashes.

Fruit	Price	Advantages
Bananas	first line	first line
	next line	next line
Bananas	first line	first line
	next line	next line