



"Fast Diameter Computation of Large Sparse Graphs using GPUs"

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- 1 Diameter Computation
 - Background
 - Observations
 - An Example
 - Node Selection
- 2 Methodology
 - Parallelization
 - GPU Related Optimizations
- 3 Results



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Let $G(V, E)$ be an undirected graph with nodes
 $V = \{0, \dots, n - 1\}$ and edges $E \subseteq V \times V$.



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Definition

The distance $d(\phi, \psi)$ between nodes $\phi, \psi \in V$ is the length of the shortest path that connects them. The eccentricity $\epsilon(\phi)$ of node $\phi \in V$ is the greatest distance between ϕ and any other node $\psi \in V - \{\phi\}$.



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Definition

The diameter $D(G)$ of graph G equals the maximum eccentricity of any node $\phi \in V$.



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Diameter computation using All-Pair Shortest-Path (APSP):

```

$$ecc_{all} \leftarrow \{\}$$
for all  $\phi \in V$  do  
     $ecc \leftarrow \epsilon(\phi)$   
     $ecc_{all} \leftarrow ecc_{all} + \{ecc\}$   
return  $\max(ecc_{all})$ 
```

$\max(d(\phi, V - \{\phi\}))$



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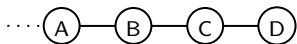
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 - Lowerbound of ψ equals $\epsilon(\phi) - d(\phi, \psi)$.
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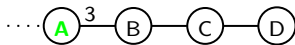
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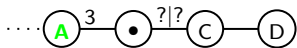
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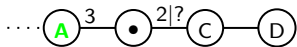
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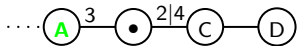
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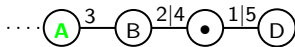
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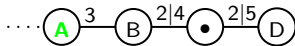
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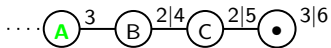
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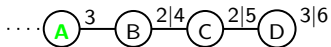
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$$\max(\epsilon(\psi) - d(\phi, \psi), d(\phi, \psi)) \leq \epsilon(\psi) \leq \epsilon(\phi) + d(\phi, \psi)$$



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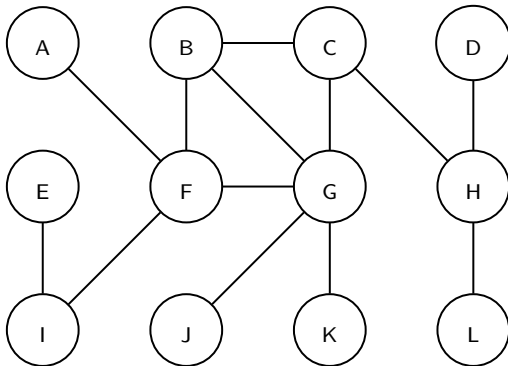
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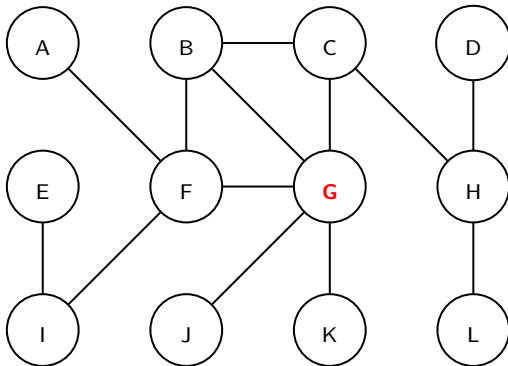


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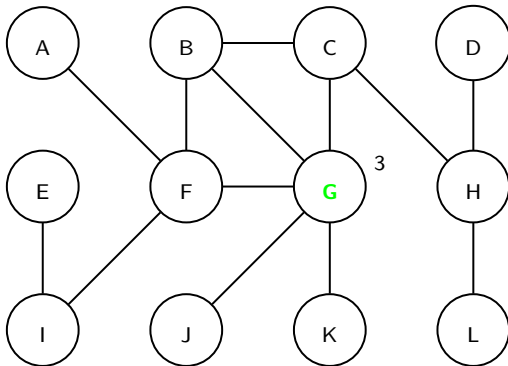
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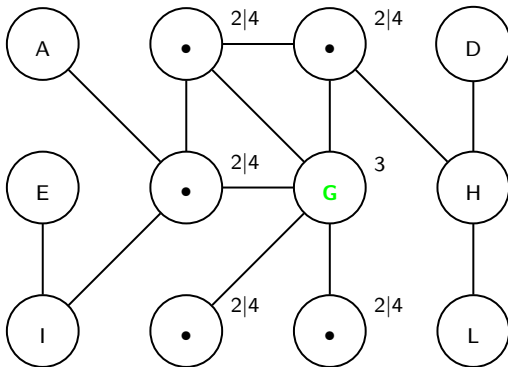
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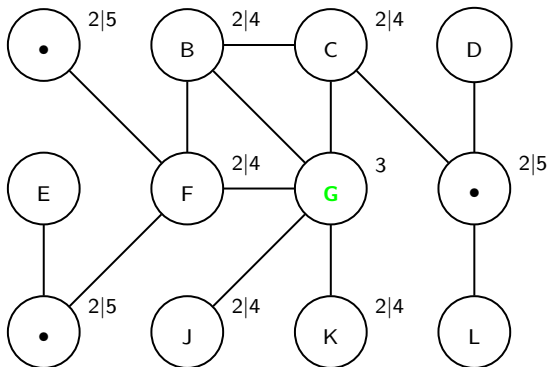


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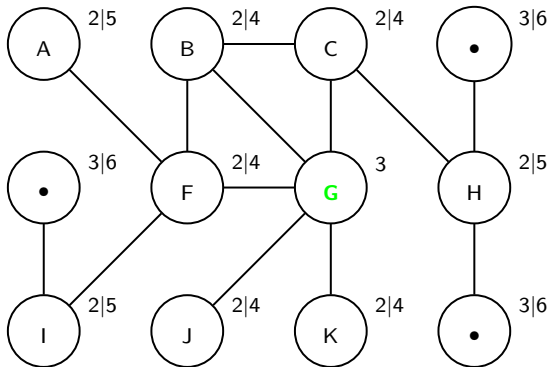
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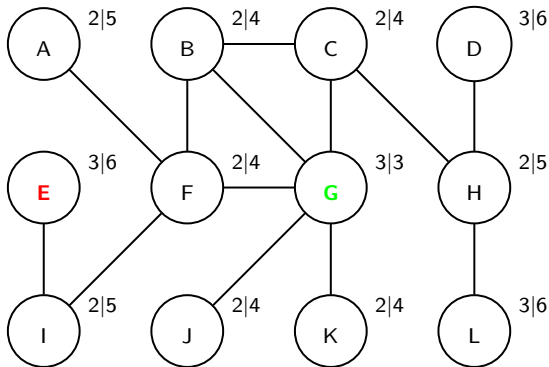
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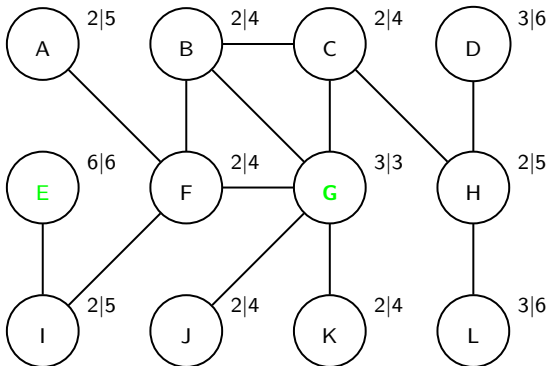
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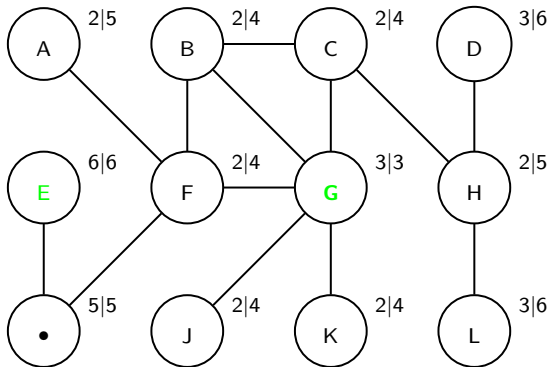
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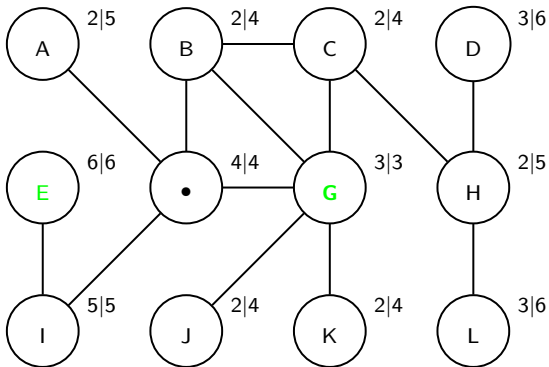
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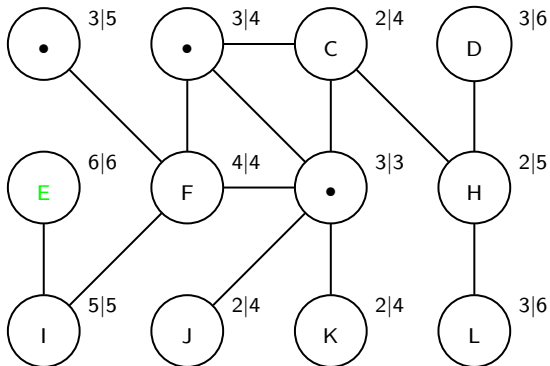
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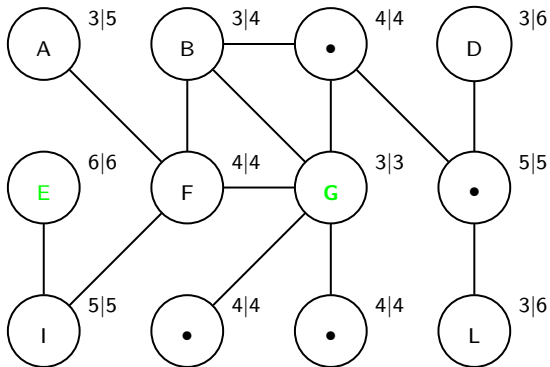
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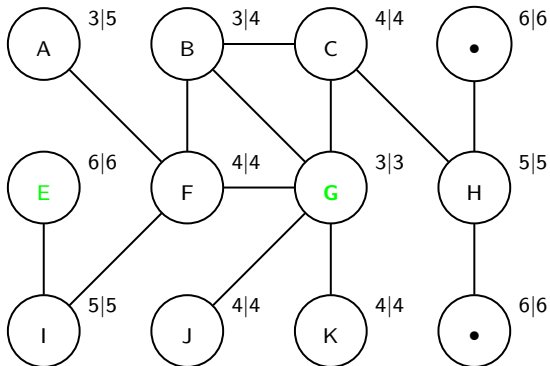
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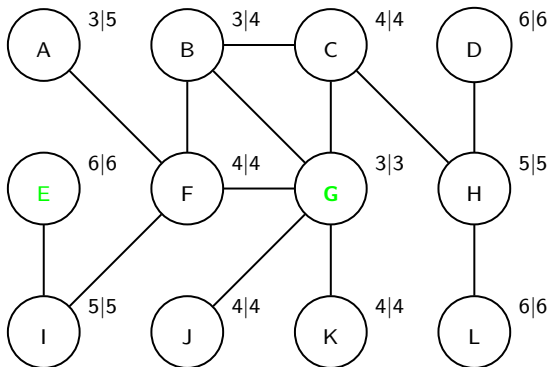


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- Eccentricity bound difference
- Interchanging eccentricity bounds
- Repeated farthest distance



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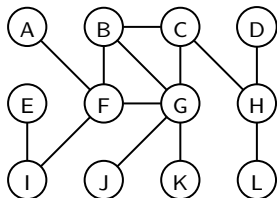
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- Node Selection
- Determine Eccentricity
- Update Bounds

	$d(\phi, *)$	B_L	B_U
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			
L			



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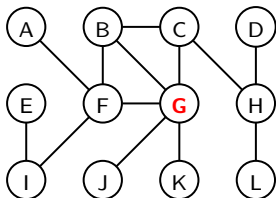
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- Node Selection $\phi = G$
- Determine Eccentricity
- Update Bounds

	$d(\phi, *)$	B_L	B_U
A			
B			
C			
D			
E			
F			
G	0		
H			
I			
J			
K			
L			



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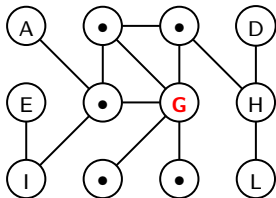
Methodology

Parallelization

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Results

Questions



- Node Selection $\phi = G$
- Determine Eccentricity
- Update Bounds

	$d(\phi, *)$	B_L	B_U
A			
•	1		
•	1		
D			
E			
•	1		
G	0		
H			
I			
•	1		
•	1		
L			



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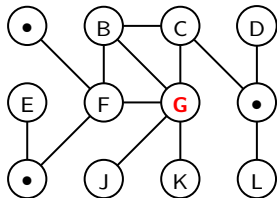
Parallelization

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Questions



- Node Selection $\phi = G$
- Determine Eccentricity
- Update Bounds

	$d(\phi, *)$	B_L	B_U
•	2		
B	1		
C	1		
D			
E			
F	1		
G	0		
•	2		
•	2		
J	1		
K	1		
L			



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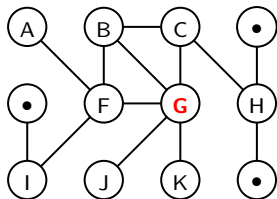
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Results

Questions



- Node Selection $\phi = G$
- Determine Eccentricity
- Update Bounds

	$d(\phi, *)$	B_L	B_U
A	2		
B	1		
C	1		
•	3		
•	3		
F	1		
G	0		
H	2		
I	2		
J	1		
K	1		
•	3		



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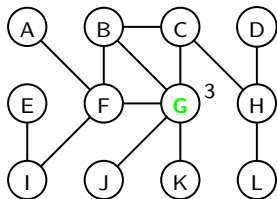
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Questions



- Node Selection $\phi = G$
- Determine Eccentricity $\epsilon(G) = 3$
- Update Bounds

	$d(\phi, *)$	B_L	B_U
A	2		
B	1		
C	1		
D	3		
E	3		
F	1		
G	0		
H	2		
I	2		
J	1		
K	1		
L	3		



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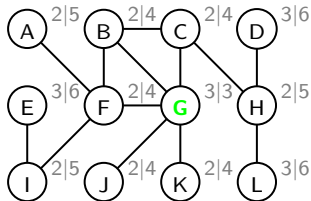
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- Node Selection $\phi = G$
- Determine Eccentricity $\epsilon(G) = 3$
- Update Bounds
 - $\max(\epsilon(\phi) - d(\phi, \psi), d(\phi, \psi))$
 - $\epsilon(\phi) + d(\phi, \psi)$

	$d(\phi, *)$		B_L	B_U
A	2	→	2	5
B	1	→	2	4
C	1	→	2	4
D	3	→	3	6
E	3	→	3	6
F	1	→	2	4
G	0	→	3	3
H	2	→	2	5
I	2	→	2	5
J	1	→	2	4
K	1	→	2	4
L	3	→	3	6



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■ Node Selection

- Element-wise array difference
- Max value of array (parallel reduction)

■ Determine eccentricity

- Parallel breadth first search
- Max value of array (parallel reduction)

■ Update bounds

- Element-wise array addition/substraction



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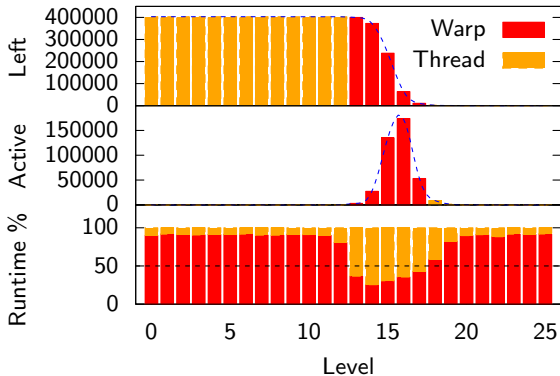


Figure : Measures to determine best algorithm type



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Performance Analysis

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Component	Avg runtime %	Avg speedup
Initialization	0.09	39.96
Node selection	1.17	11.70
Eccentricity	97.13	5.55
Updating bounds	1.29	46.59
Node Pruning	0.31	46.38



Experiments & Results

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Dataset	n_{WCC}	m_{WCC}	D	D_{90}	I	T	S	$SAPSP$
Amazon0601	403364	3387224	21	7.6	28	143.68	13.34	14405.86
as-skitter	1694616	11094209	25	5.9	6	138.85	8.75	282436.00
cit-Patents	3764117	16511741	22	9.4	111	4515.64	21.11	33910.96
com-amazon	334863	925872	44	15	7	24.71	11.95	47837.57
com-dblp	317080	1049866	22	8.1	8	21.78	13.56	39635.00
com-LiveJournal	3997962	34681189	18	6.4	9	519.04	16.12	444218.00
com-youtube	1134890	2987624	21	6.5	2	17.26	13.66	567445.00
Email-EuAll	224832	395270	13	4.5	3	8.95	5.85	74944.00
roadNet-CA	1957027	5520776	850	500	181	12381.40	2.45	10812.30
roadNet-PA	1087562	3083028	782	539	61	2508.87	2.22	17828.89
roadNet-TX	1351137	3758402	1049	670	83	5194.15	1.84	16278.76
soc-LiveJournal1	4843953	68983820	18	6.5	6	437.18	16.01	807325.50
soc-Pokec	1632803	30622564	11	5.3	3	110.88	14.01	544267.67
web-BerkStan	654782	7499425	669	10	5	153.72	2.06	130956.40
web-Google	855802	5066842	22	8.1	5	47.38	12.25	171160.40
web-NotreDame	325729	1497134	46	9.3	3	16.35	4.05	108576.33
web-Stanford	255265	2234572	740	9.8	7	111.23	1.88	36466.43
WikiTalk	2388953	5018445	9	4	7	97.02	11.07	341279.00



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