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BRICS – Efficient Techniques for Estimating the Farness-Centrality in Parallel

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Why Graphs?

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Farness Centrality

For a node v in graph G(u,v), it is the sum

of the shortest distances from node v to all other nodes in the graph.

$$farness[u] = \sum_{v \in V} d(u, v)$$

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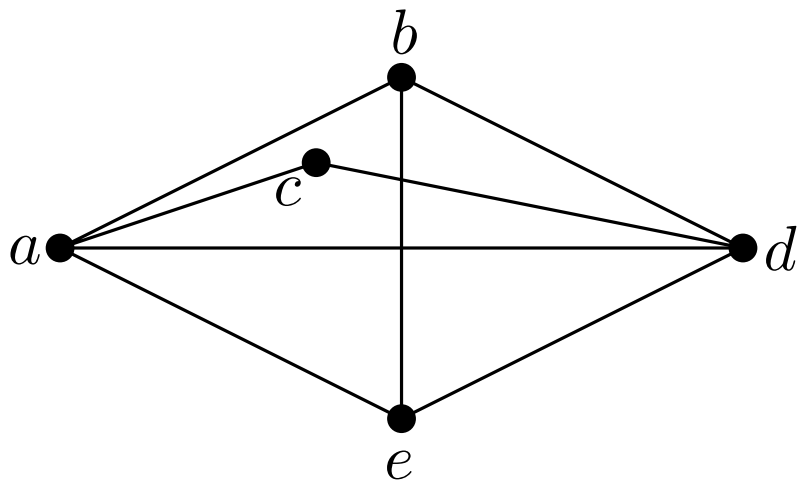
Farness Centrality

Example



	a	b	c	d	e	FC
a						
b						
c						
d						
e						

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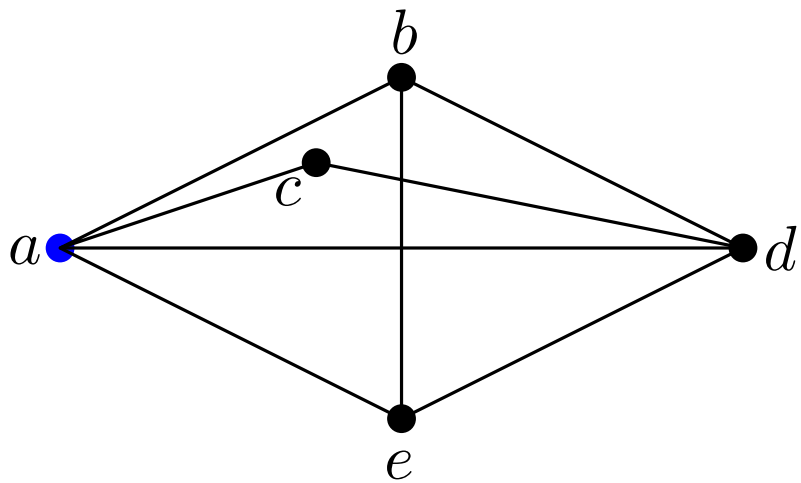
Farness Centrality

Example



	a	b	c	d	e	FC
a	0	1	1	1	1	**4**
b						
c						
d						
e						

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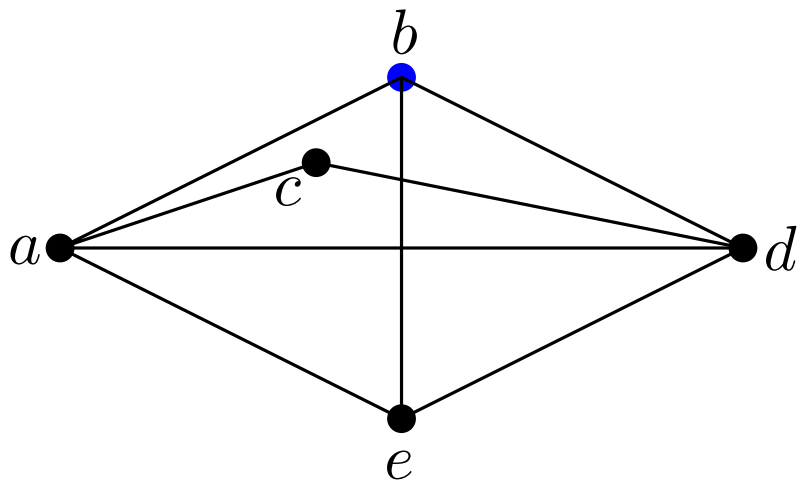
Farness Centrality

Example



	a	b	c	d	e	FC
a	0	1	1	1	1	**4**
b	1	0	2	1	1	**5**
c						
d						
e						

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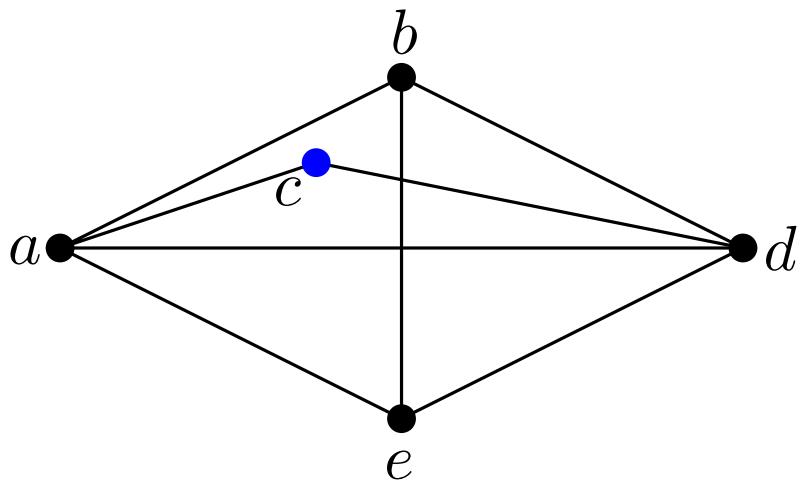
Farness Centrality

Example



	a	b	c	d	e	FC
a	0	1	1	1	1	**4**
b	1	0	2	1	1	**5**
c	1	2	0	1	2	**6**
d						
e						

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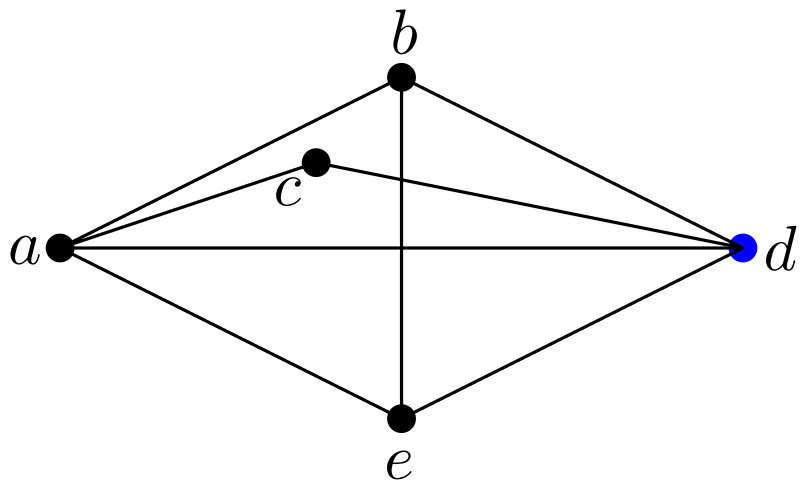
Farness Centrality

Example



	a	b	c	d	e	FC
a	0	1	1	1	1	**4**
b	1	0	2	1	1	**5**
c	1	2	0	1	2	**6**
d	1	1	1	0	1	**4**
e						

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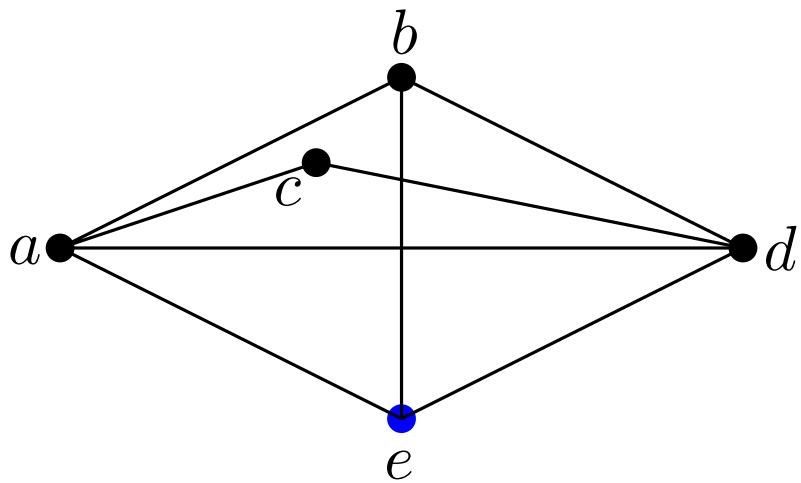
Farness Centrality

Example



	a	b	c	d	e	FC
a	0	1	1	1	1	**4**
b	1	0	2	1	1	**5**
c	1	2	0	1	2	**6**
d	1	1	1	0	1	**4**
e	1	1	2	1	0	**5**

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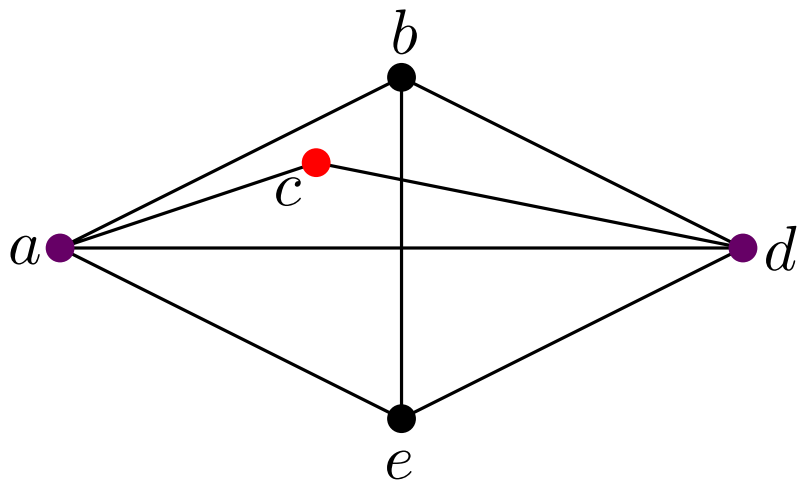
Farness Centrality

Example



	a	b	c	d	e	FC
a	0	1	1	1	1	**4**
b	1	0	2	1	1	**5**
c	1	2	0	1	2	**6**
d	1	1	1	0	1	**4**
e	1	1	2	1	0	**5**

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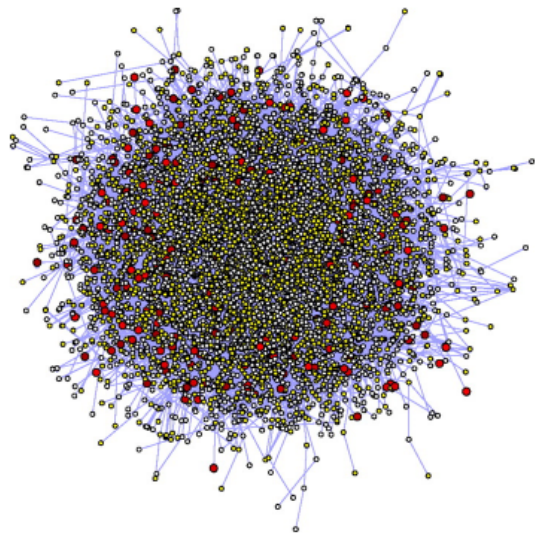
Why Approximate FC?

- Time complexity:
  - FC: $O(nm)$
  - Approx FC: $O(km)$

10M nodes graph



  - FC: 2 - 3 days
  - Approx FC: 3 - 5 Hrs

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Related Work

- Eppstein et al: Random-K, first randomized Approximation of Centrality.(1999)

- Cohen et al: Hybrid method of sampling and pivoting to estimate the closeness centrality.

- Sariyuce et al: BADIOS framework for computing exact betweenness centrality.

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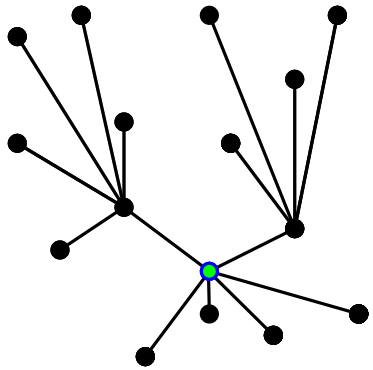
Approaches



Exact FC

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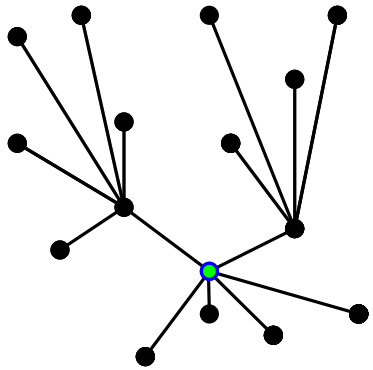
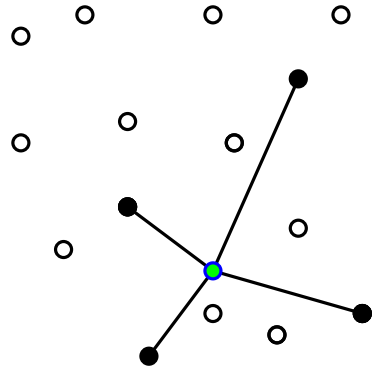
Approaches



Exact FC



Approx FC(Random-K)

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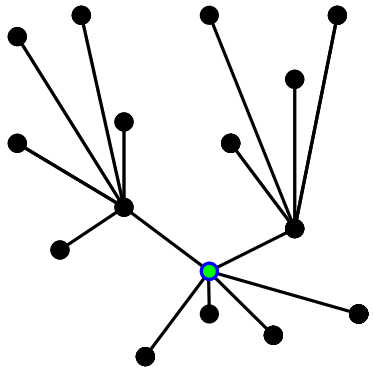
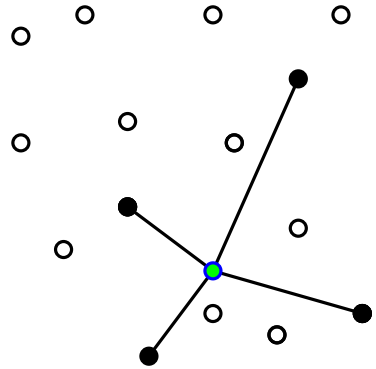
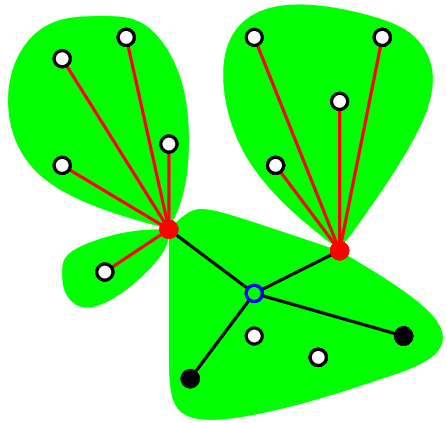
Approaches



Exact FC



Approx FC(Random-K)



Our Approach(BRICS)

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Our Techniques

BRICS-FrameWork

- BCT
- Redundant Nodes 3D & 4D
- Identical Nodes
- Chaining

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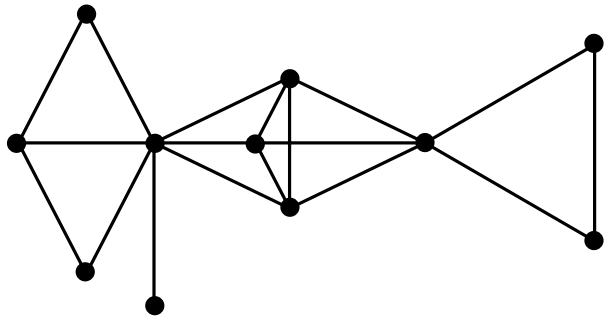
BCC based approach

Graph G



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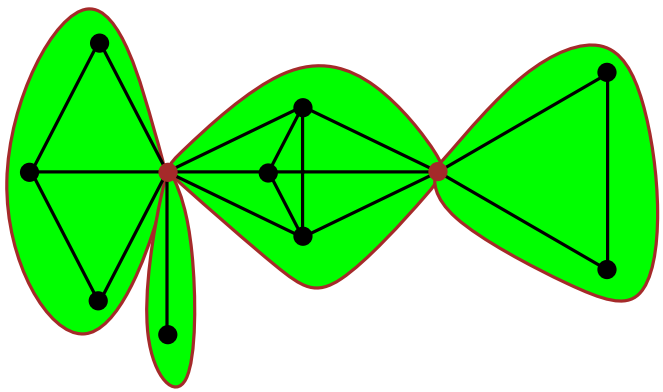
BCC based approach

BCC(G)



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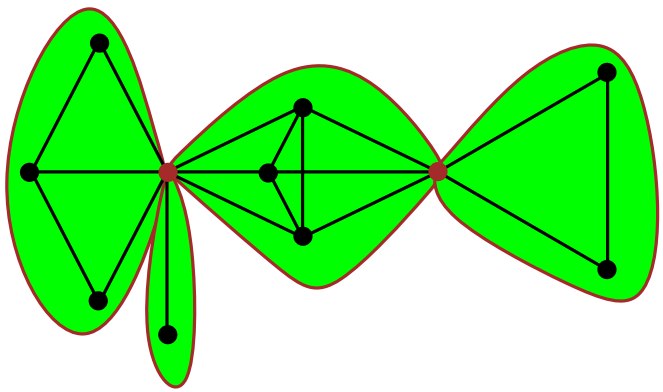
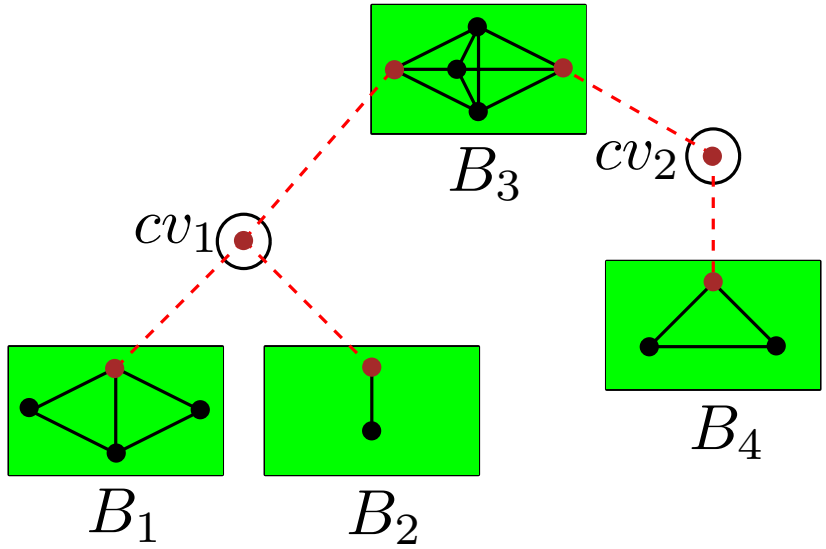
BCC based approach

BCC(G)



BCT(G)



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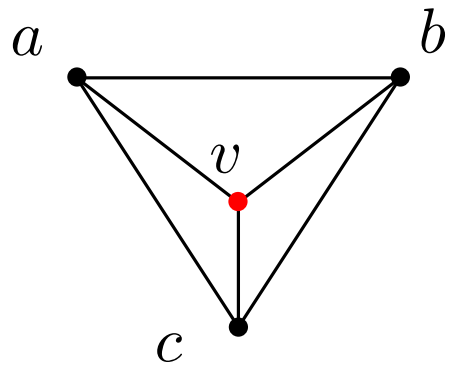
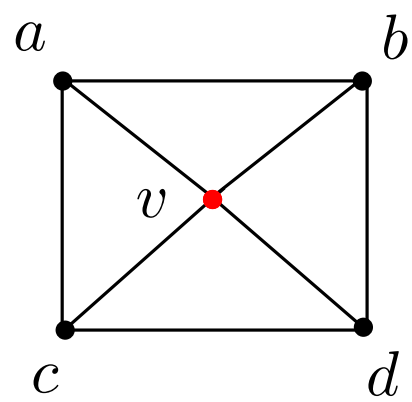
Our Techniques

Redundant Nodes





No shortest path pass through v, unless v is source/destination in R3, similarly in R4.

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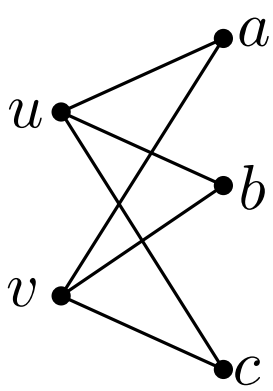
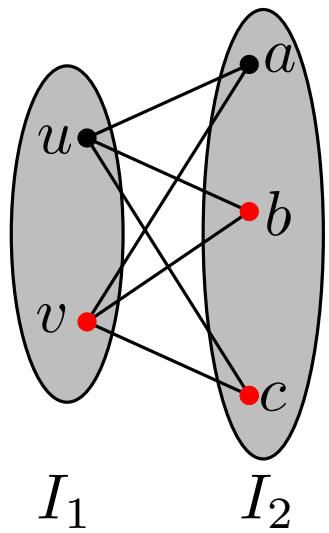
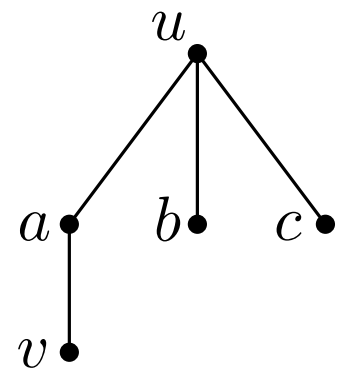
Our Techniques

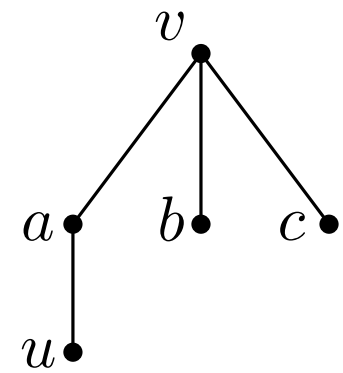
Identical Nodes







BFS(u)



BFS(v)

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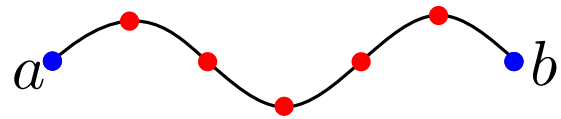
Our Techniques

Chain Nodes



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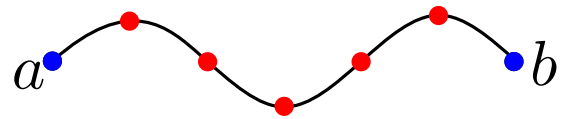
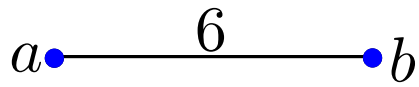
Our Techniques

Chain Nodes





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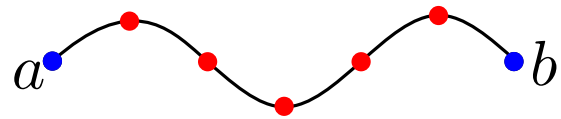
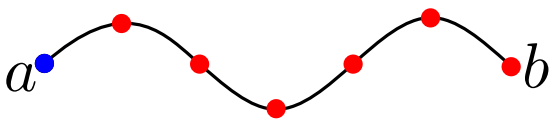
Our Techniques

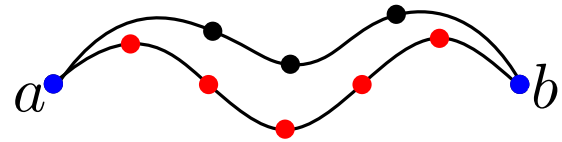
Chain Nodes



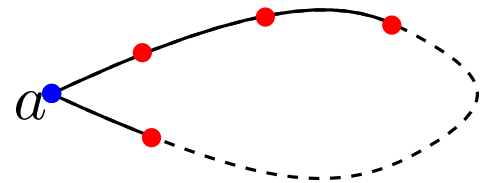
Type-1



Type-2



Type-3



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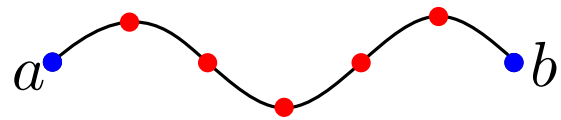
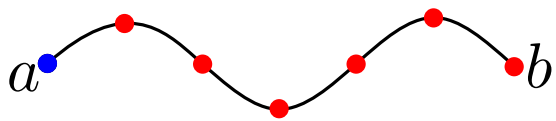
Our Techniques

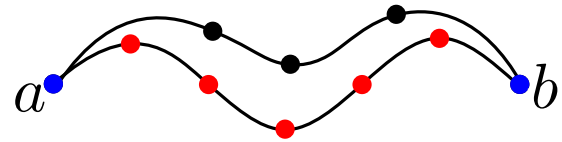
Chain Nodes



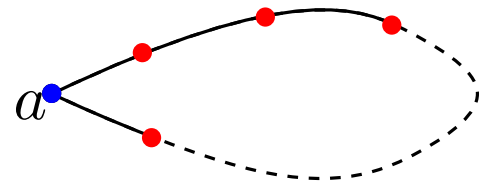
Type-1



Type-2



Type-3



All the redundant nodes can be removed directly from Graph G.

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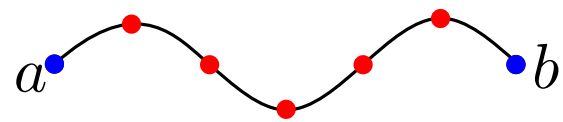
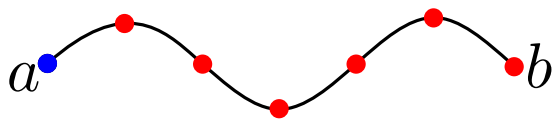
Our Techniques

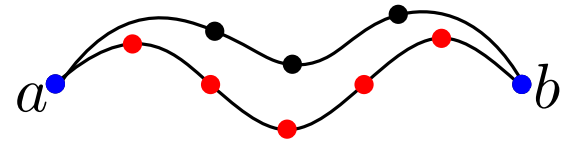
Chain Nodes



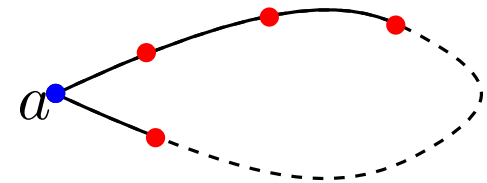
Type-1



Type-2



Type-3



All the redundant nodes can be removed directly from Graph G.

Upto 60% of total chains are of Type-2 and 80% are redundant nodes.

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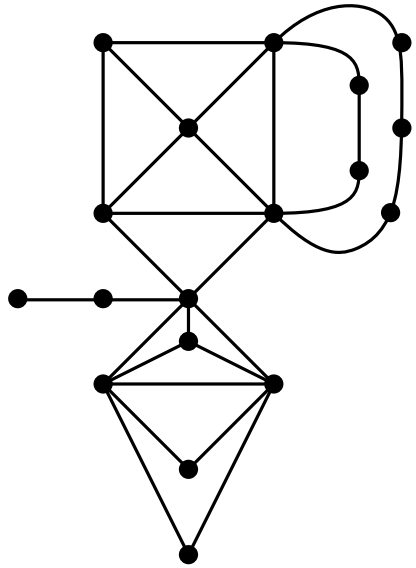
Putting Together

Procedure



G

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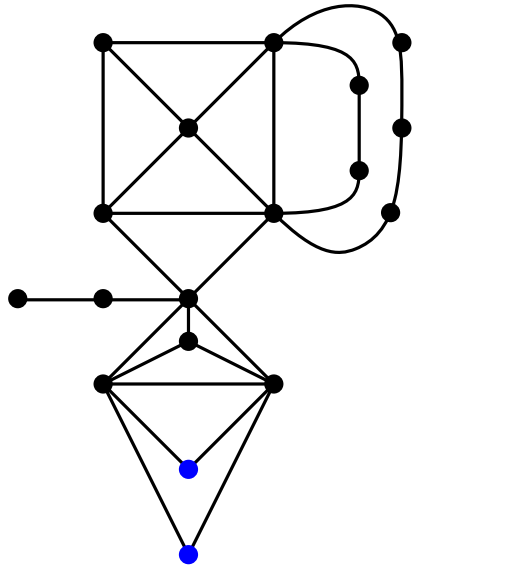
Putting Together

Procedure



G $\longrightarrow$

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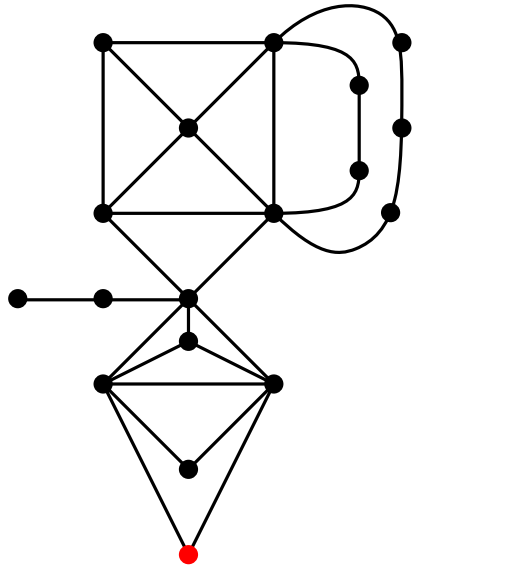
Putting Together

Procedure



$G \xrightarrow{-I}$

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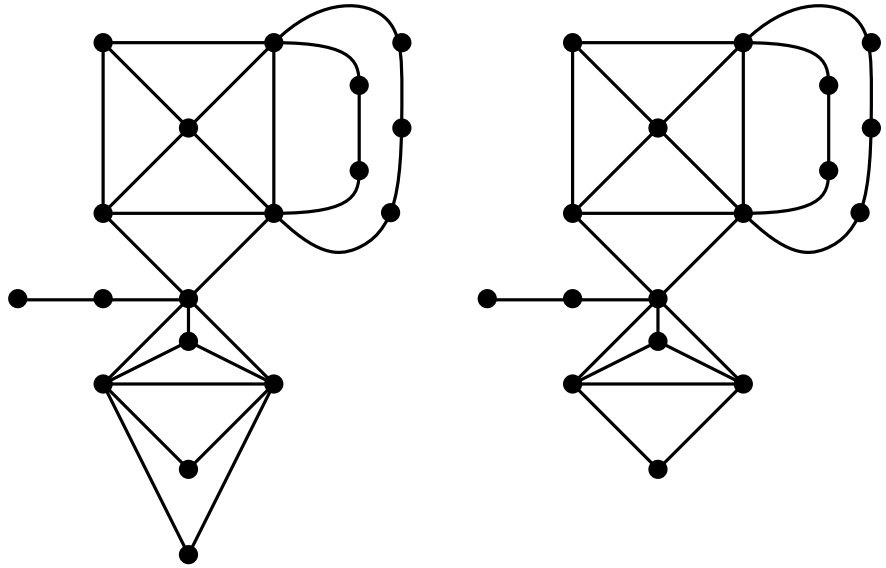
Putting Together

Procedure



$$G \xrightarrow{-I} G$$

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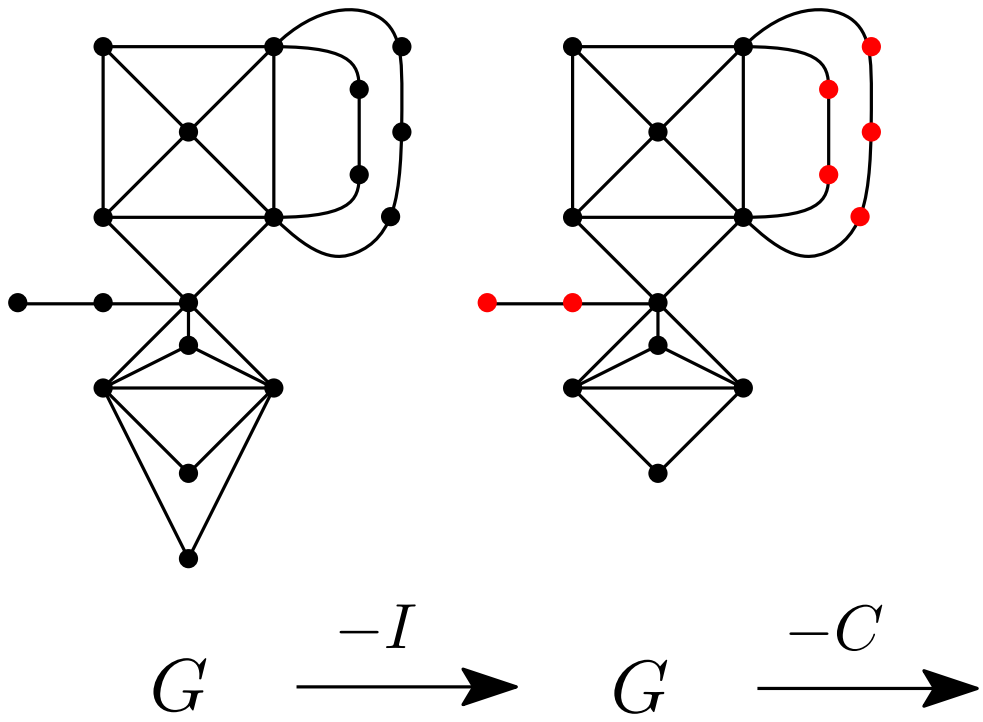
Procedure



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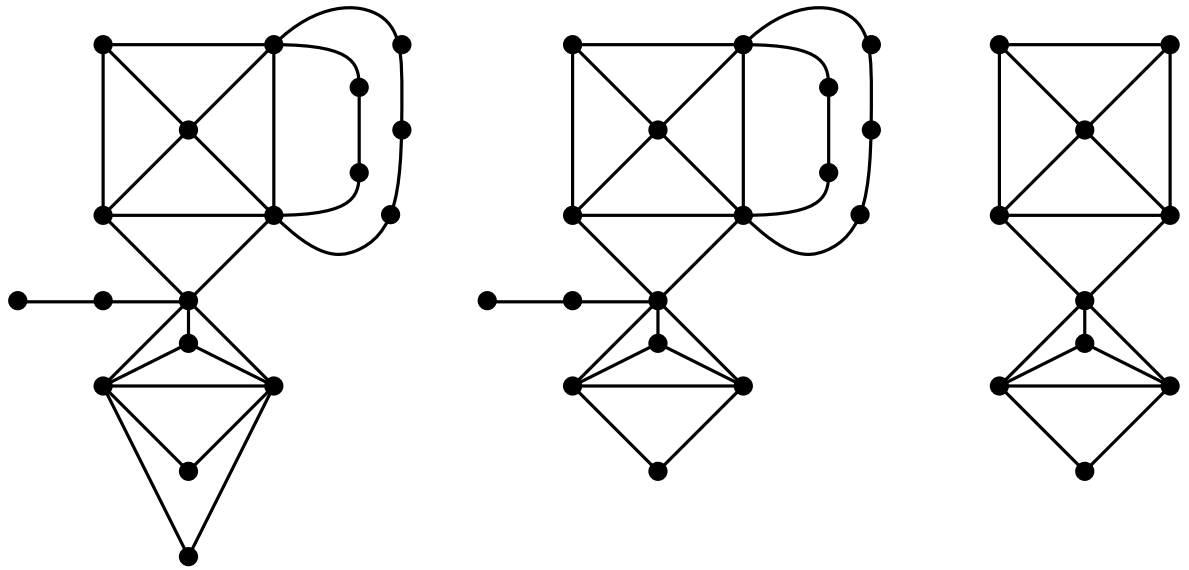
Putting Together

Procedure



$$G \xrightarrow{-I} G \xrightarrow{-C} G$$

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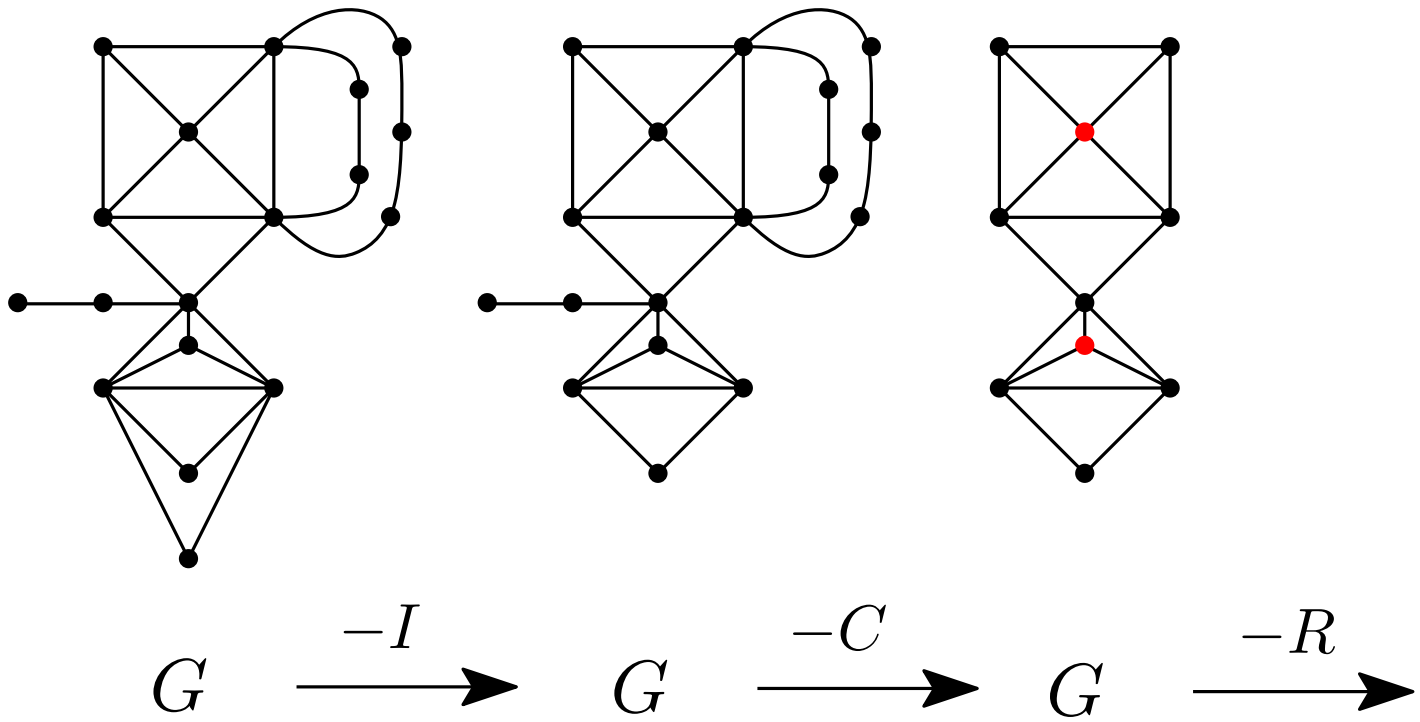
Procedure



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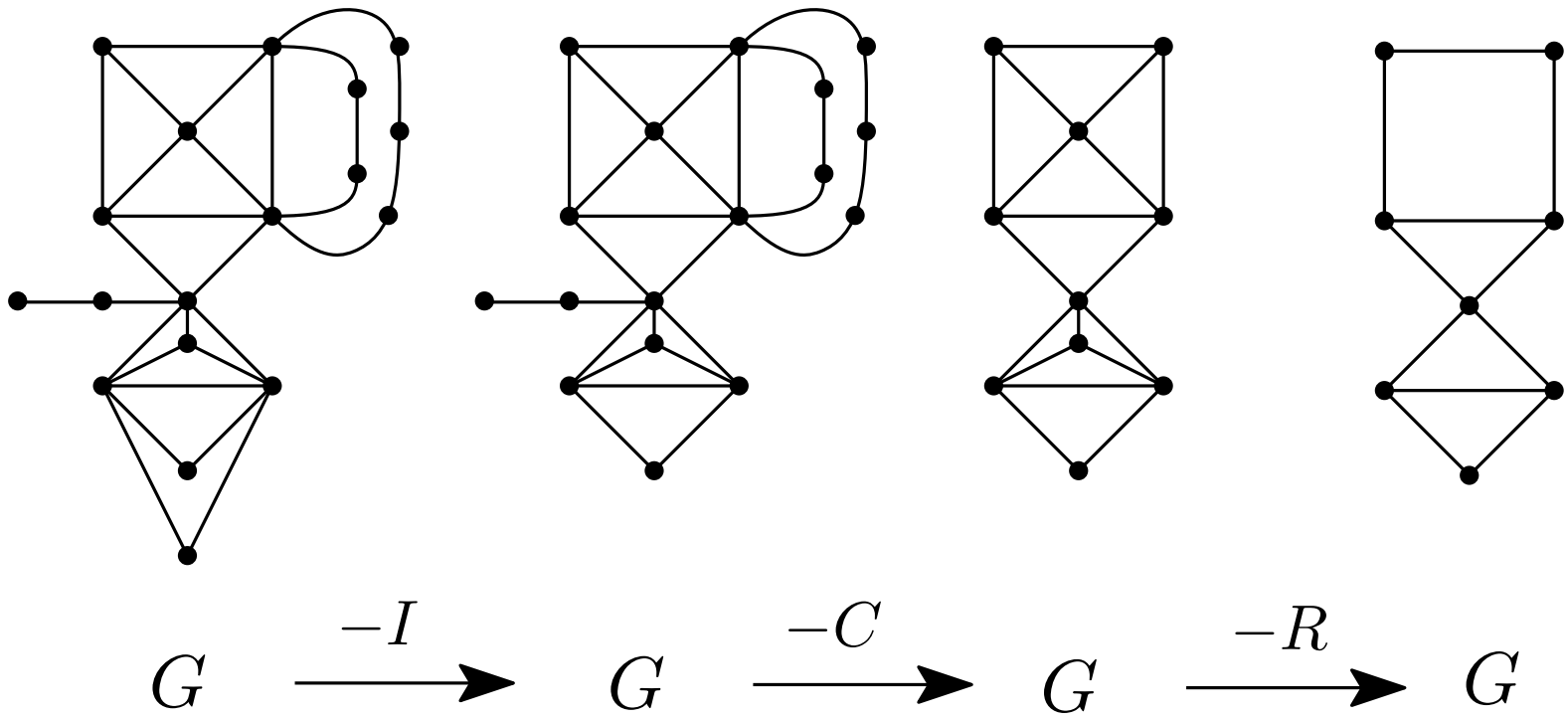
Putting Together

Procedure



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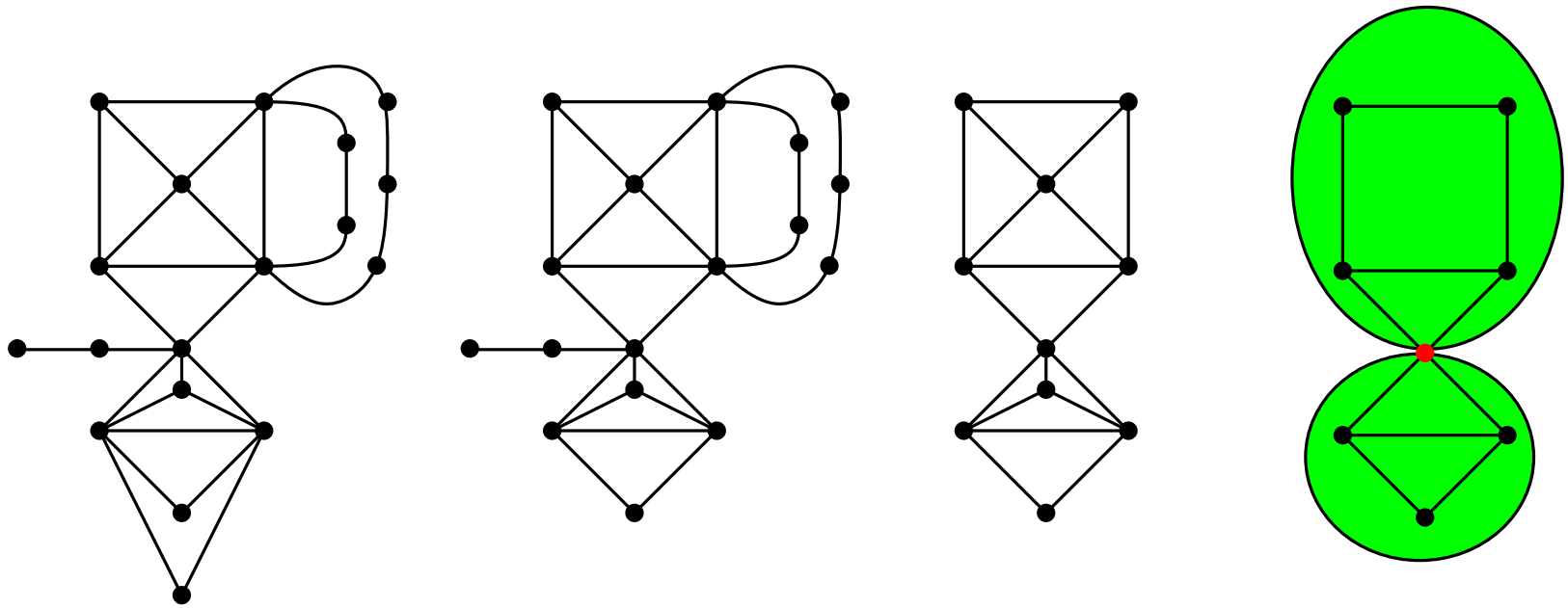
Putting Together

Procedure



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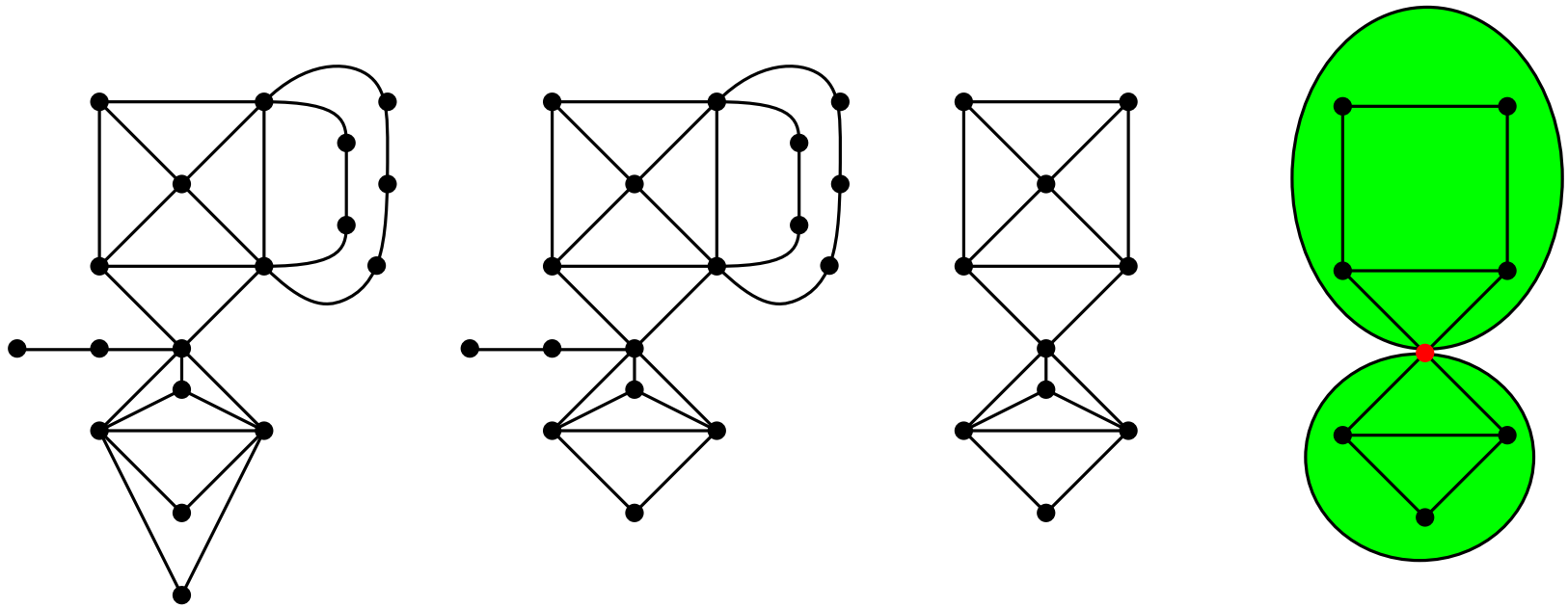
Putting Together

Procedure



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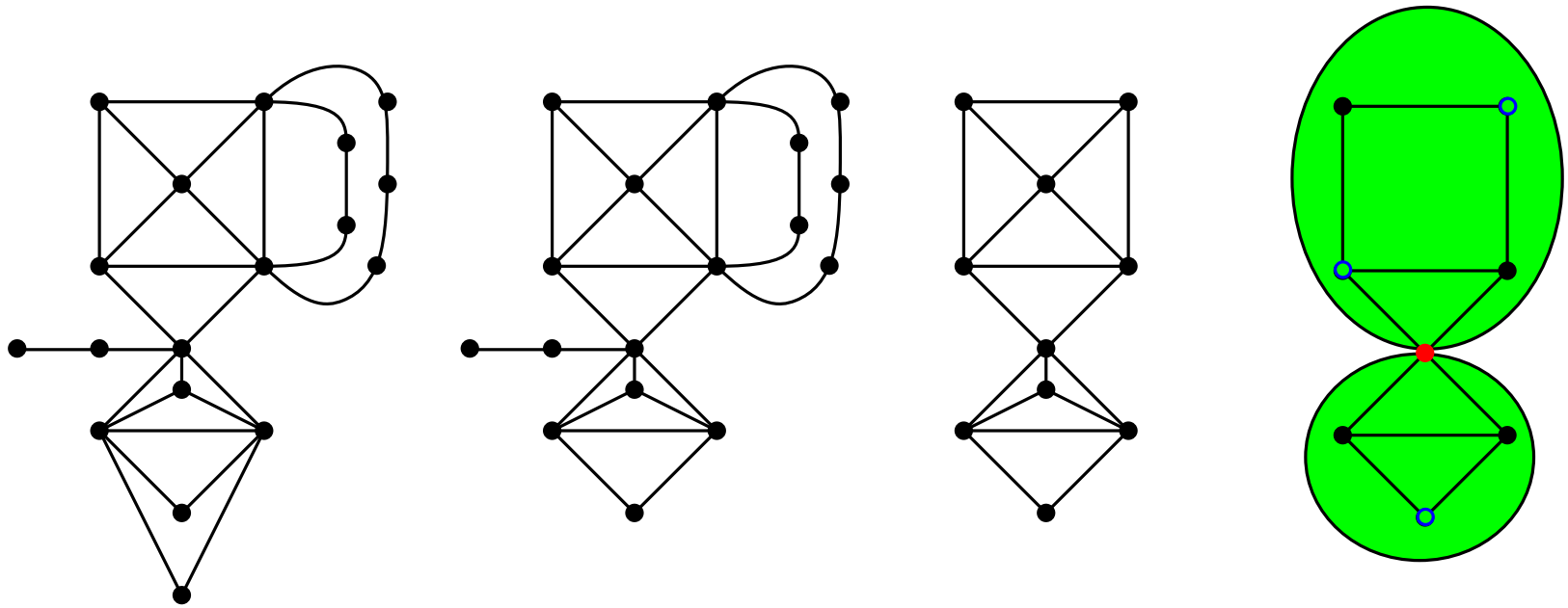
Procedure



$$G \xrightarrow{-I} G \xrightarrow{-C} G \xrightarrow{-R} G$$

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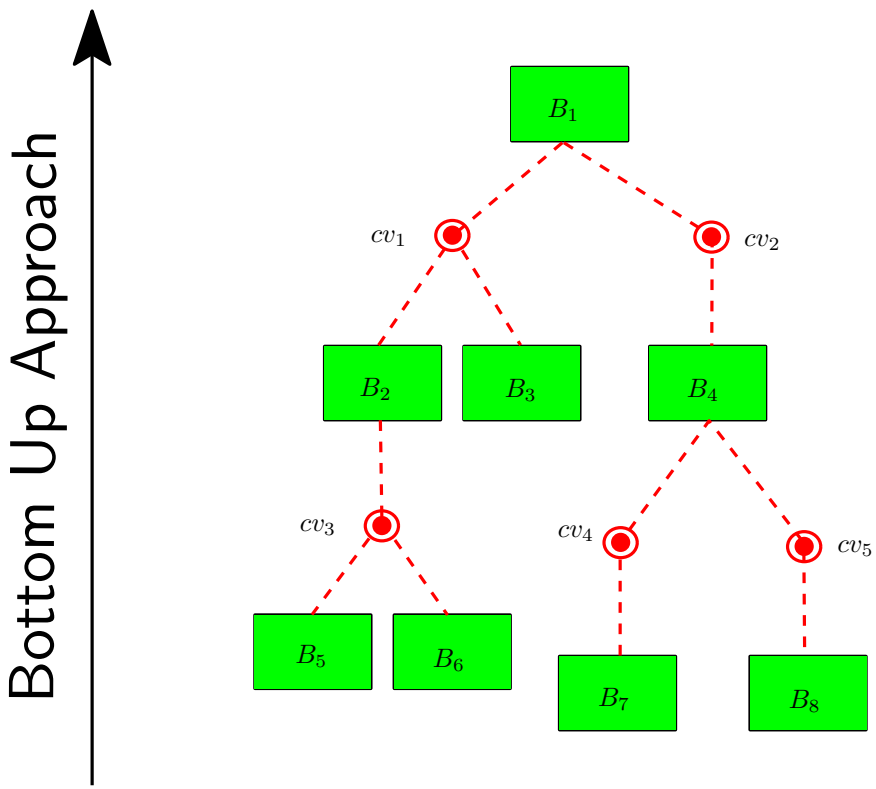

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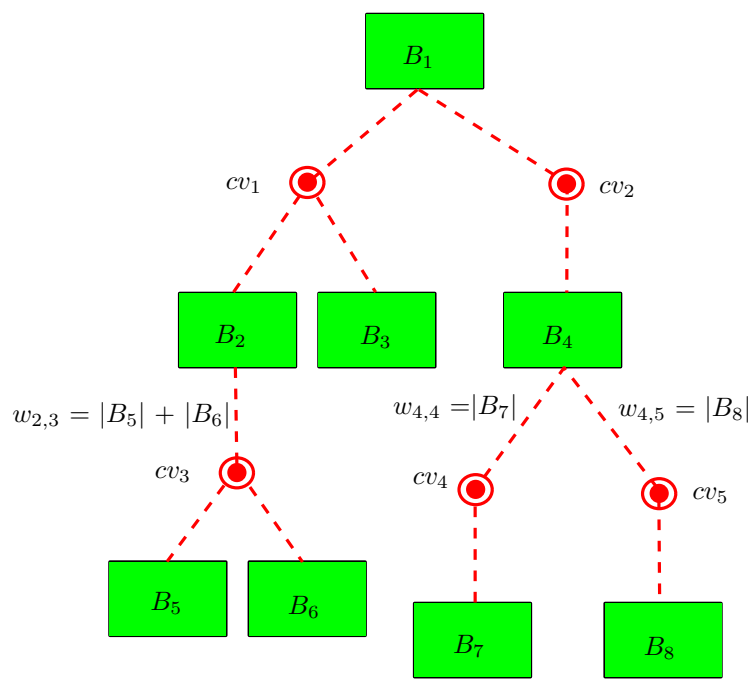
Putting Together

Procedure

Bottom Up Approach



Top Down Approach

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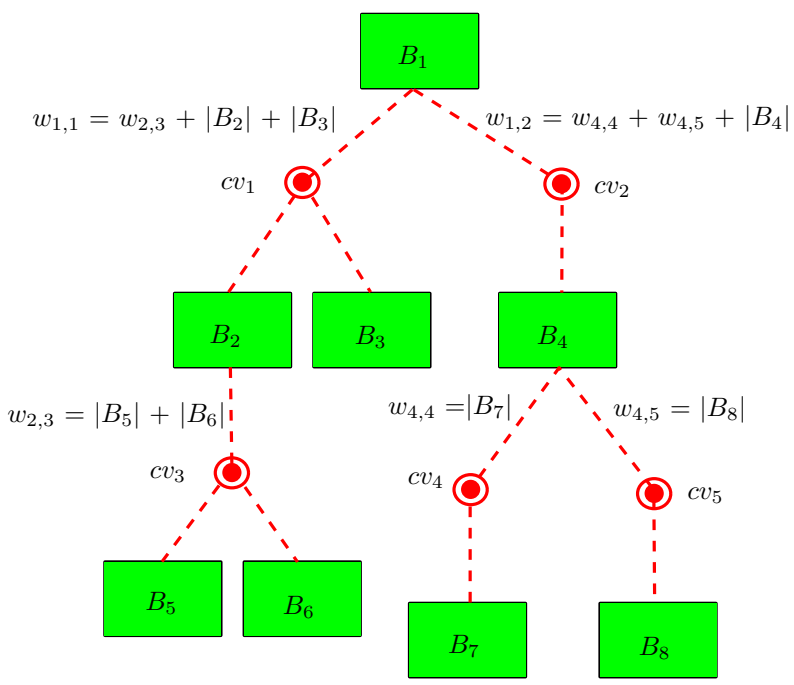
Putting Together

Procedure

Bottom Up Approach



Top Down Approach

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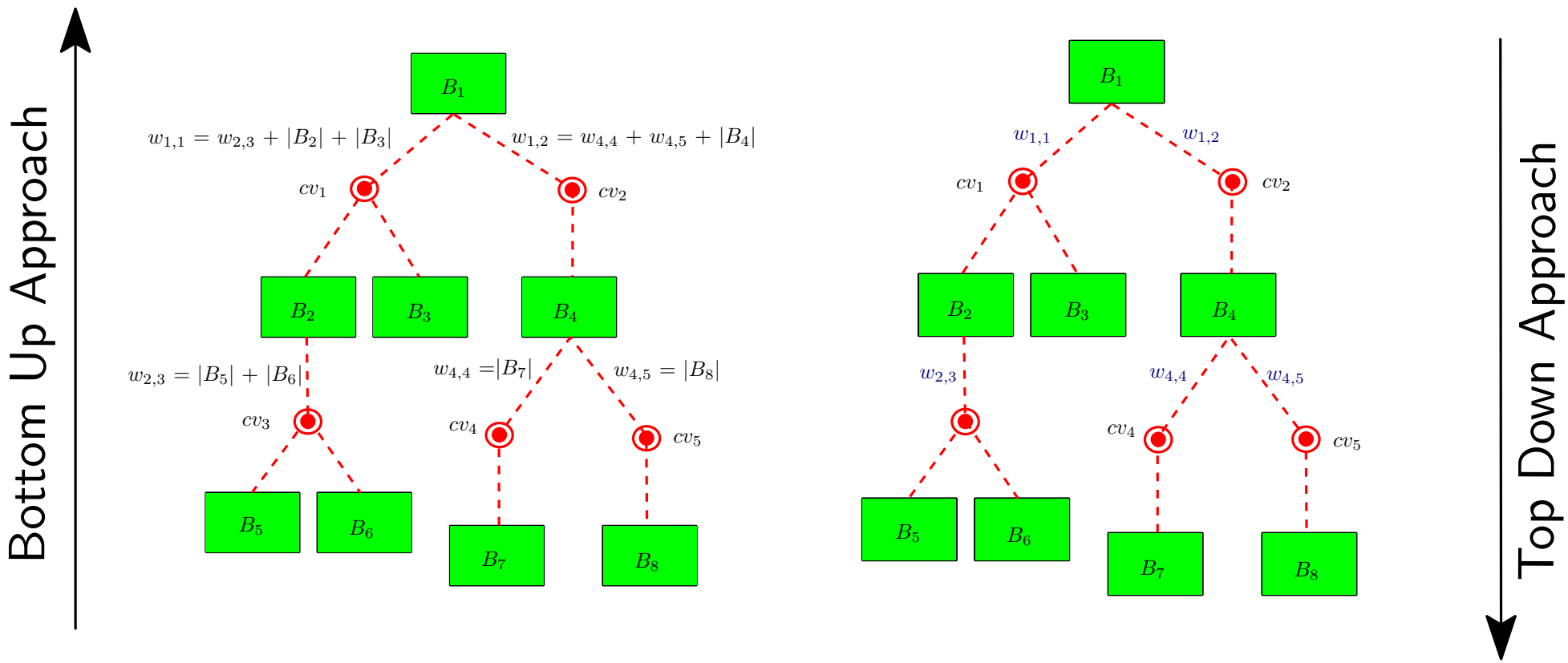
Putting Together

Procedure



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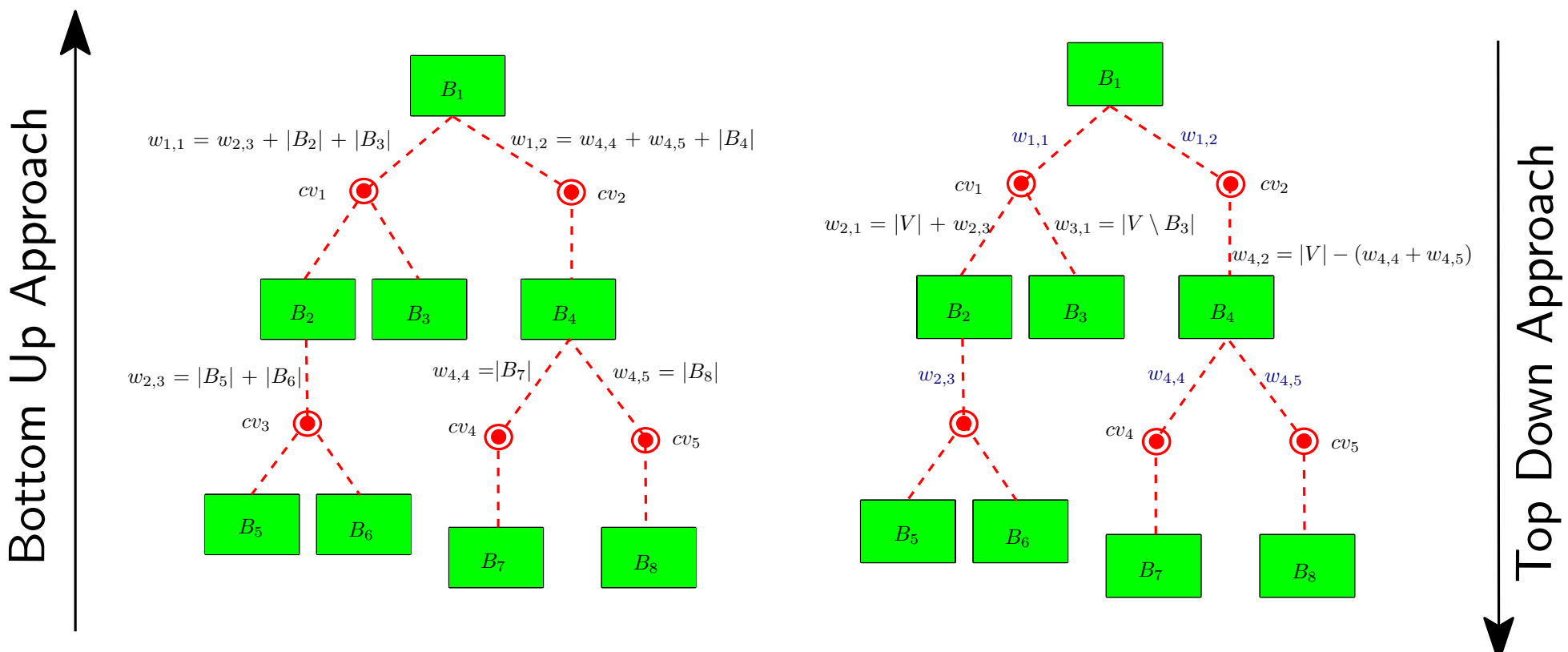
Procedure



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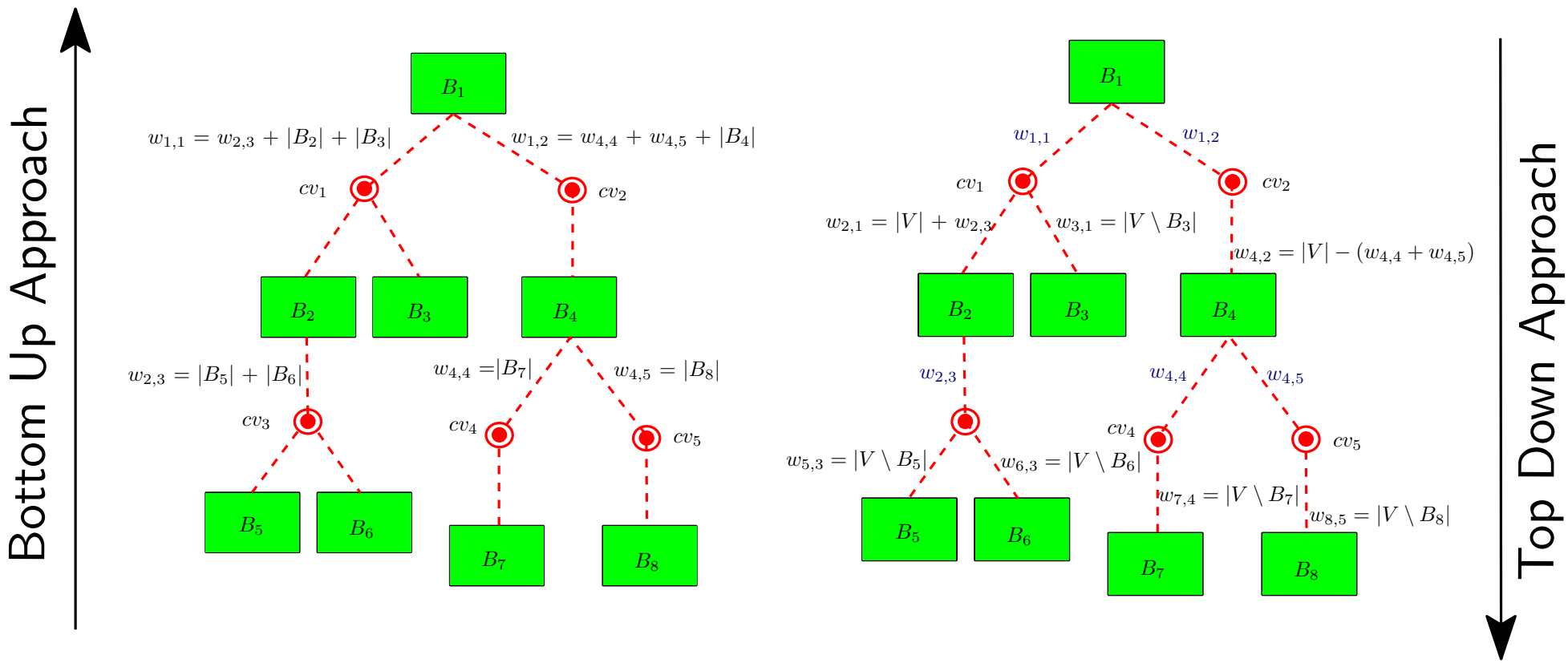

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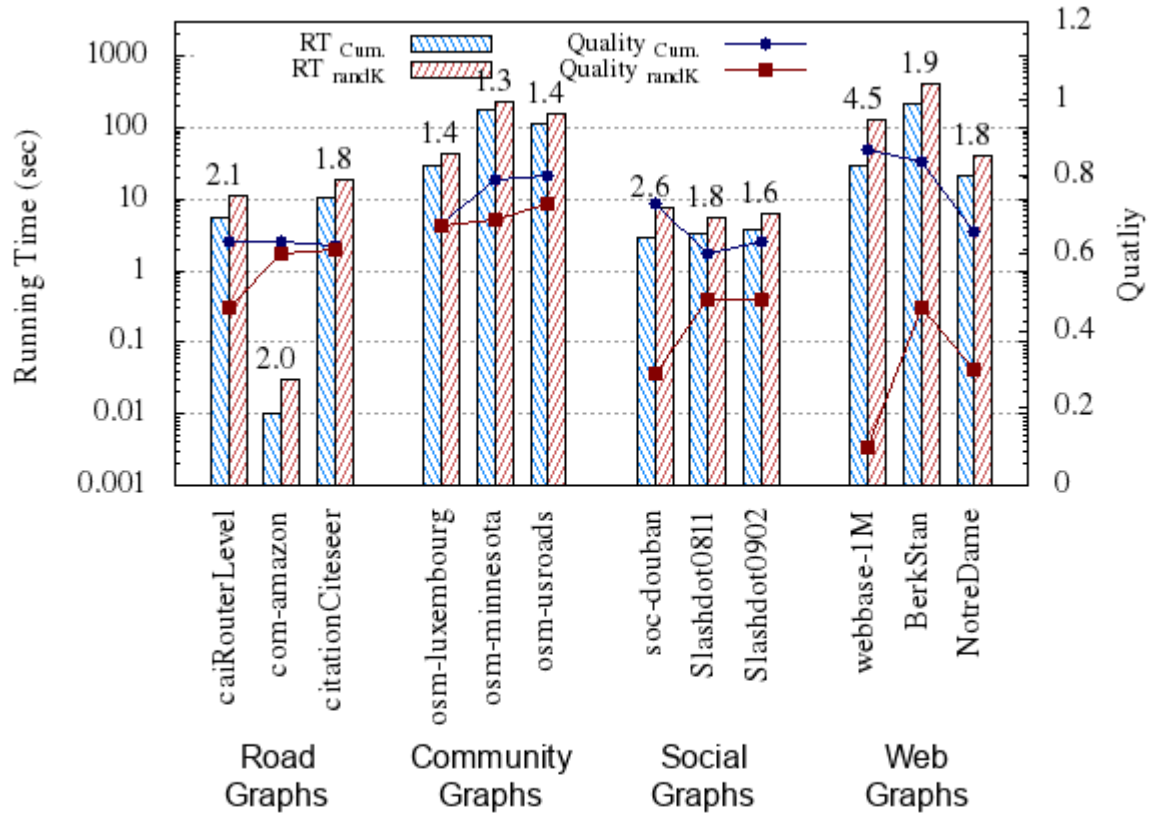
Results

Speed up Vs Quality

$$\text{Quality} = \frac{\sum_{v \in V} AR(v)}{n} \text{ where } AR(v) = \frac{farness\_estimated(v)}{farness\_actual(v)}$$



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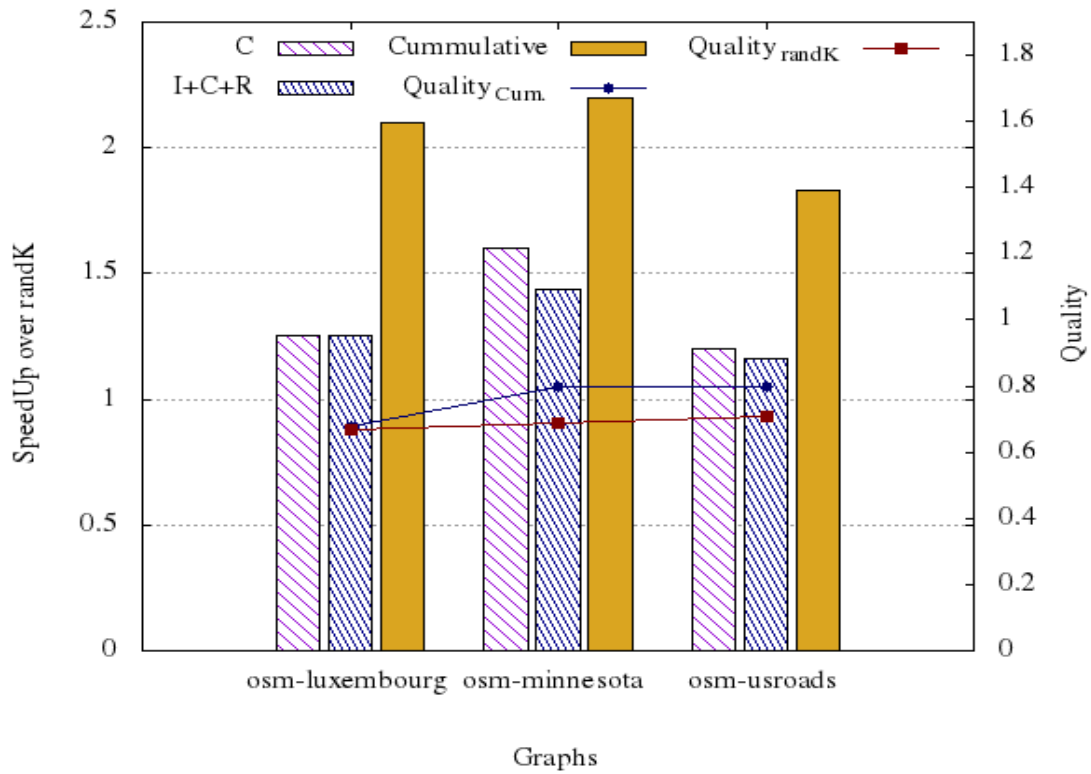
Results

Profiling for Road Networks



I & R $<$ 1% C: 70 - 85% and Largest BiCC 90%

Distribution of BiCC: Skewed, Slightly better quality

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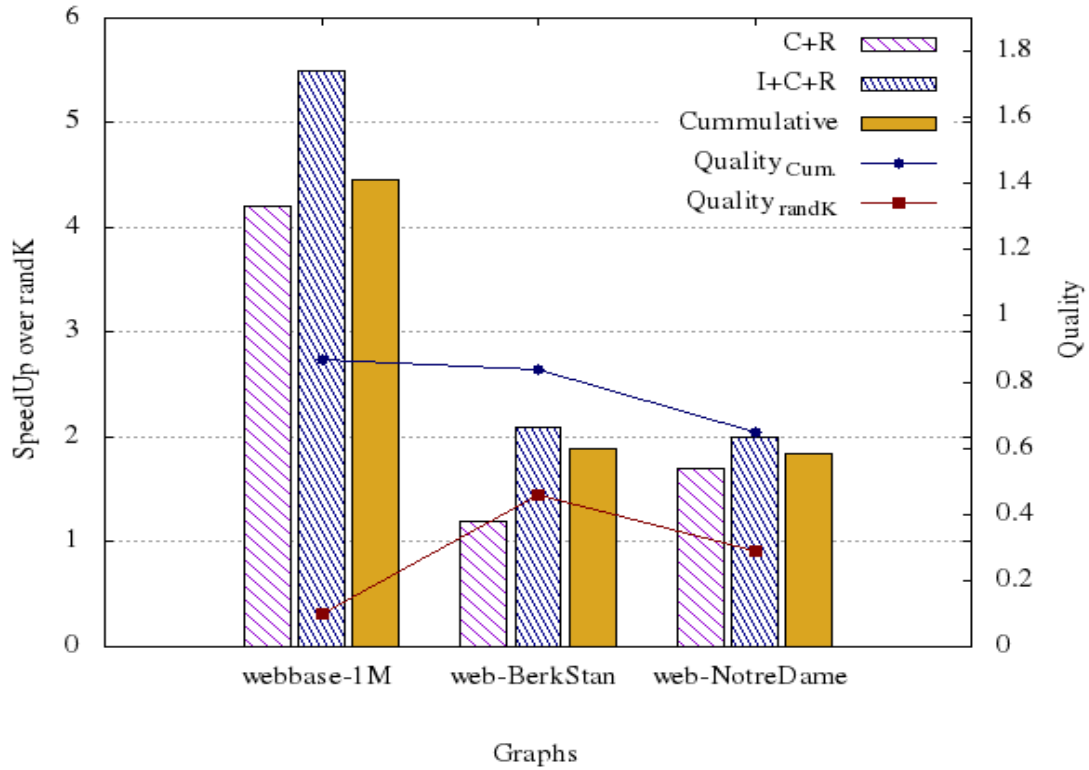
Results

Profiling for Web graphs



I: 44 %, C: 54%, R: 2.4 % and Large BiCC 27.3 % Nodes

Distribution of BiCC: nearly balanced, better quality

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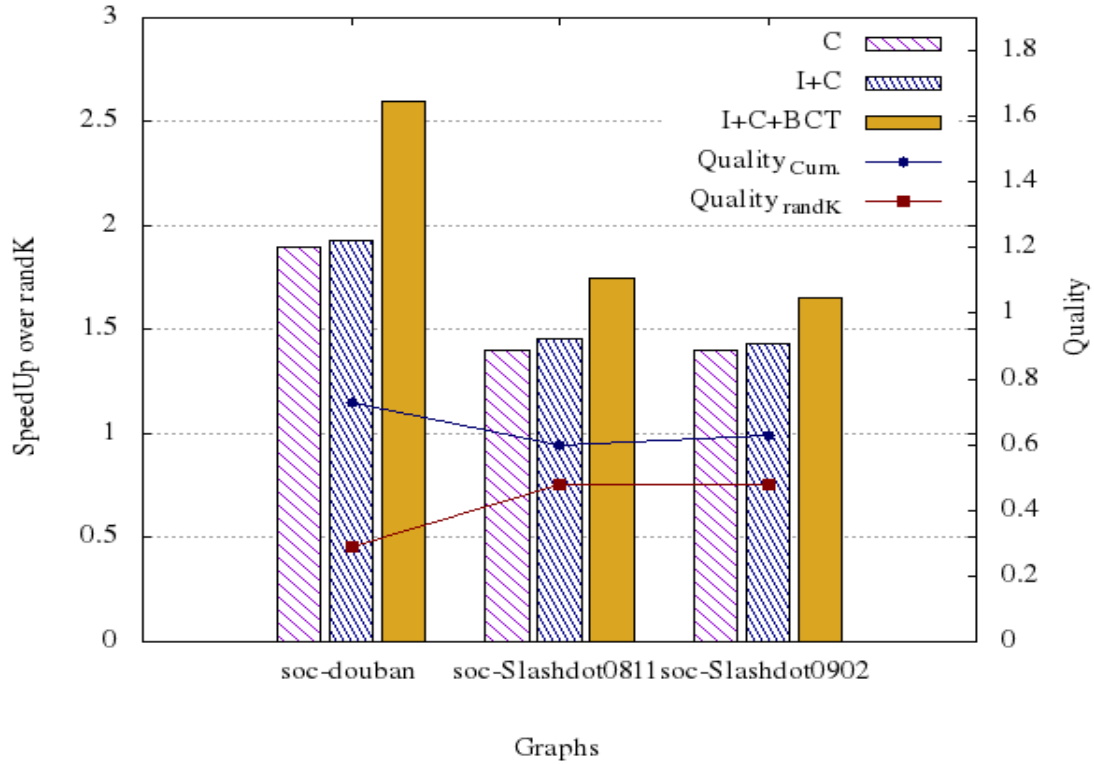
Profiling for Social graphs



I & C $\leq$ 40 % but R $<$ 1% and Large BiCC: 72 %

Distribution of BiCC: Skewed, Slightly better quality

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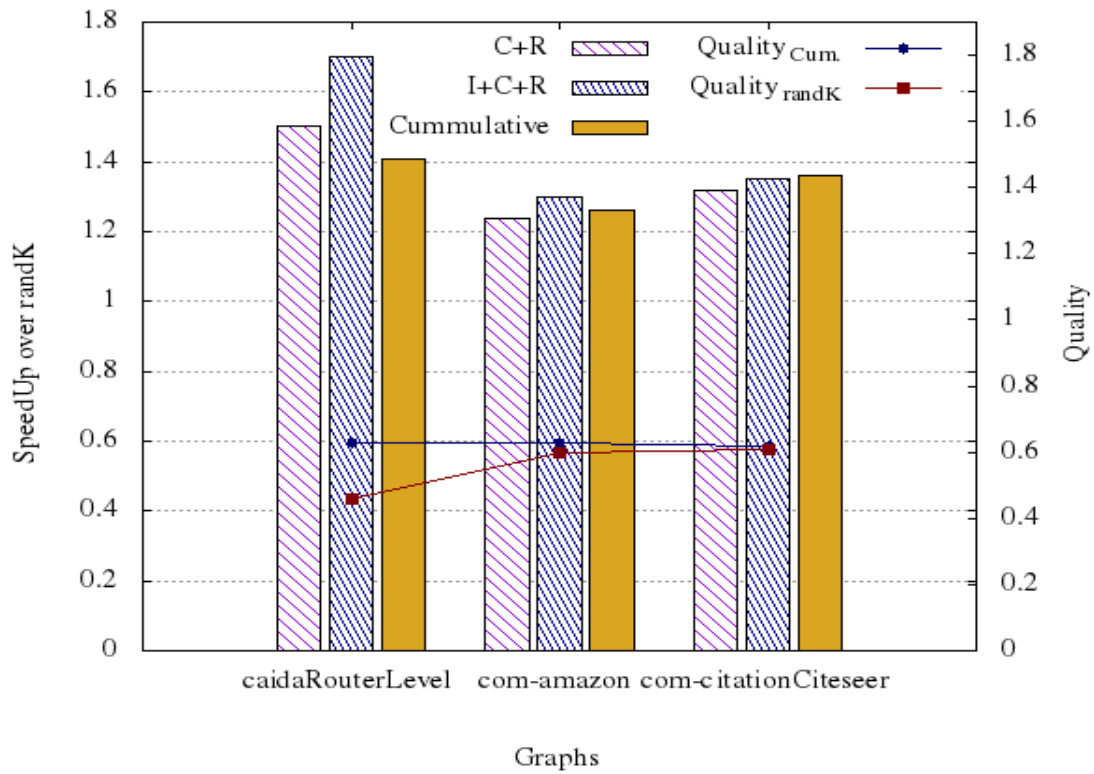
Results

Profiling for Community graphs



I, C & R $\leq$ 40 % and Large BiCC: 80 %

Distribution of BiCC: Skewed, Slightly better quality

Thank You

Questions???