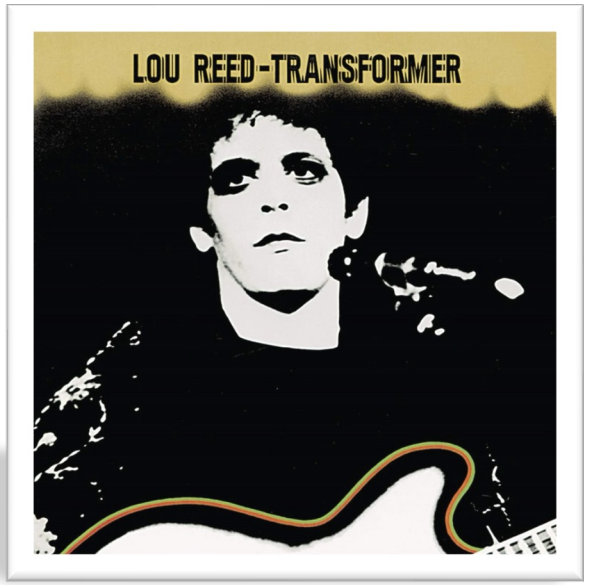
A Walk on the Wild Side: a Shape-First Methodology for Orthogonal Drawings

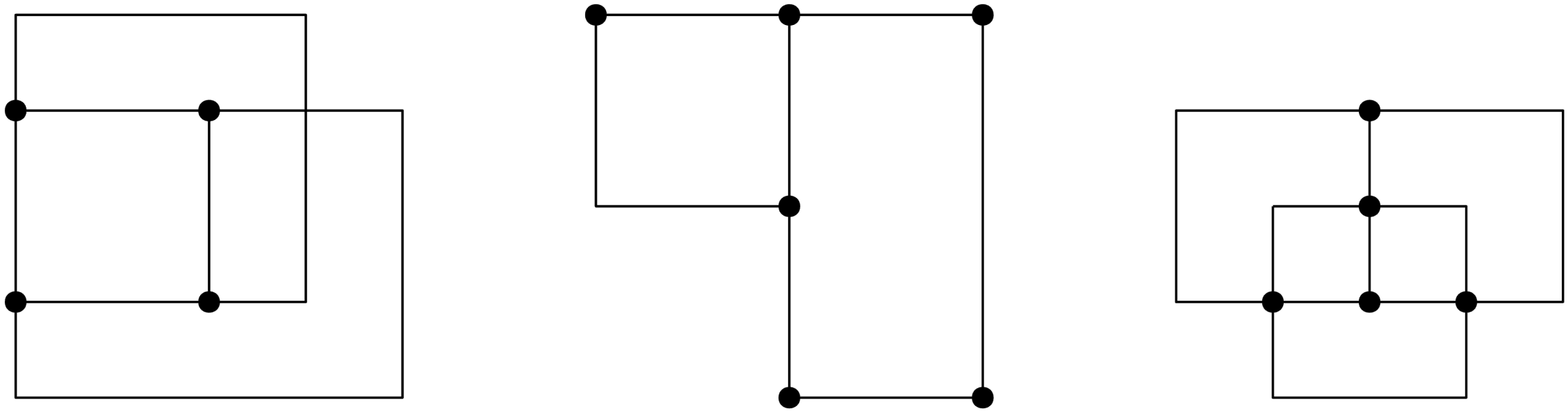


speakers: G. Andreola and A. Strippoli

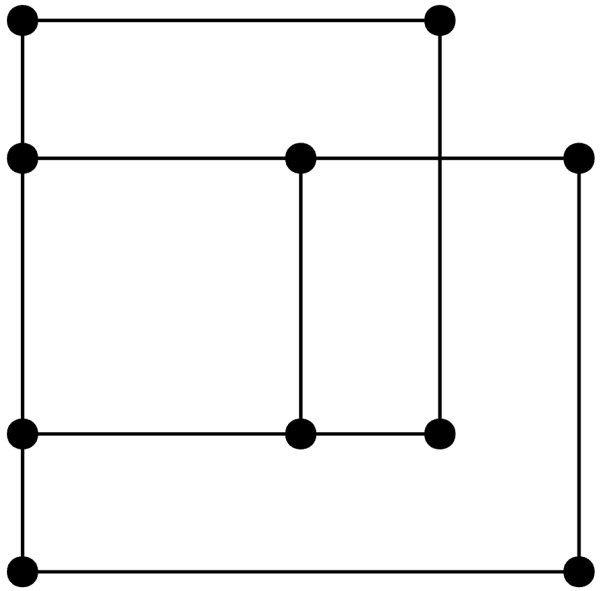
joint work with: S. Caroppo, G. Di Battista, F. Grosso, and M. Patrignani

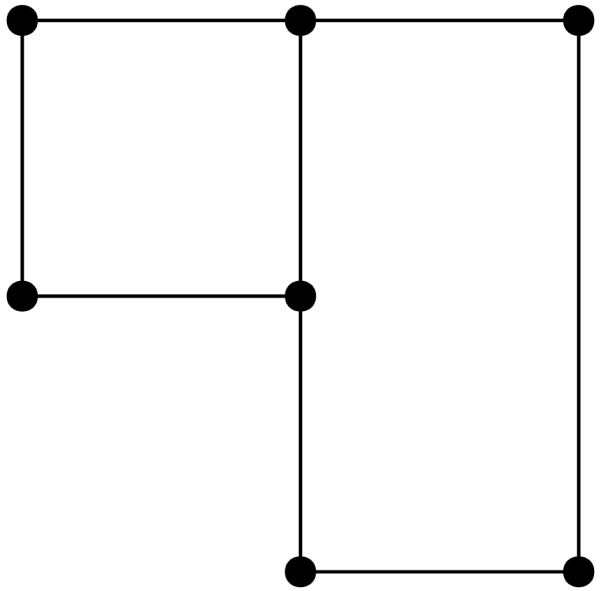
Roma Tre

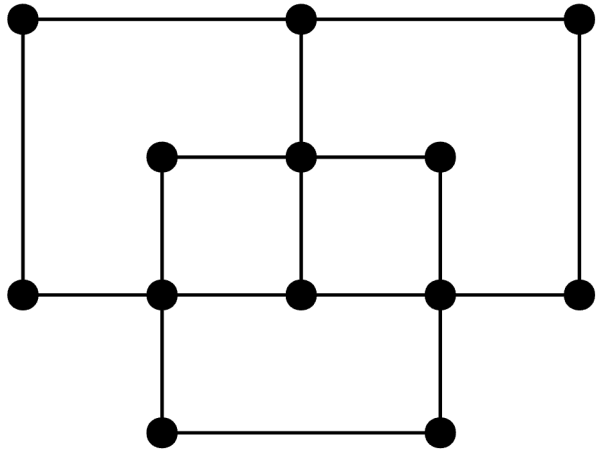
orthogonal drawing



rectilinear drawing







orthogonal drawings tools

Tom Sawyer SOFTWARE

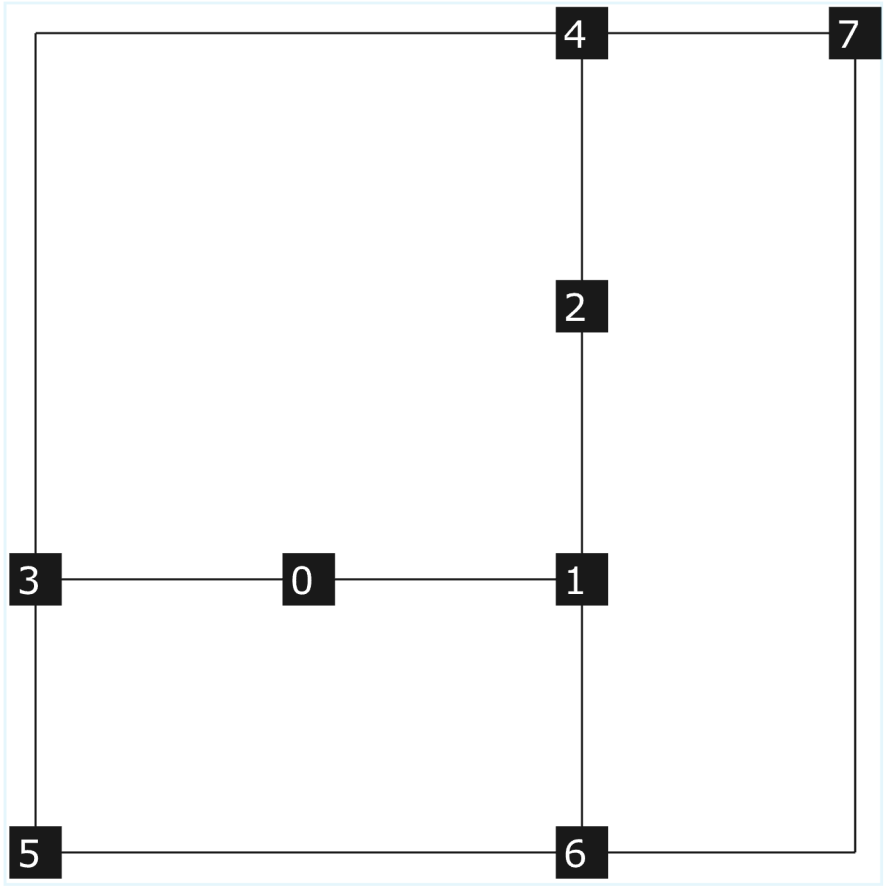
GD TOOLKIT

DOMUS

yFiles

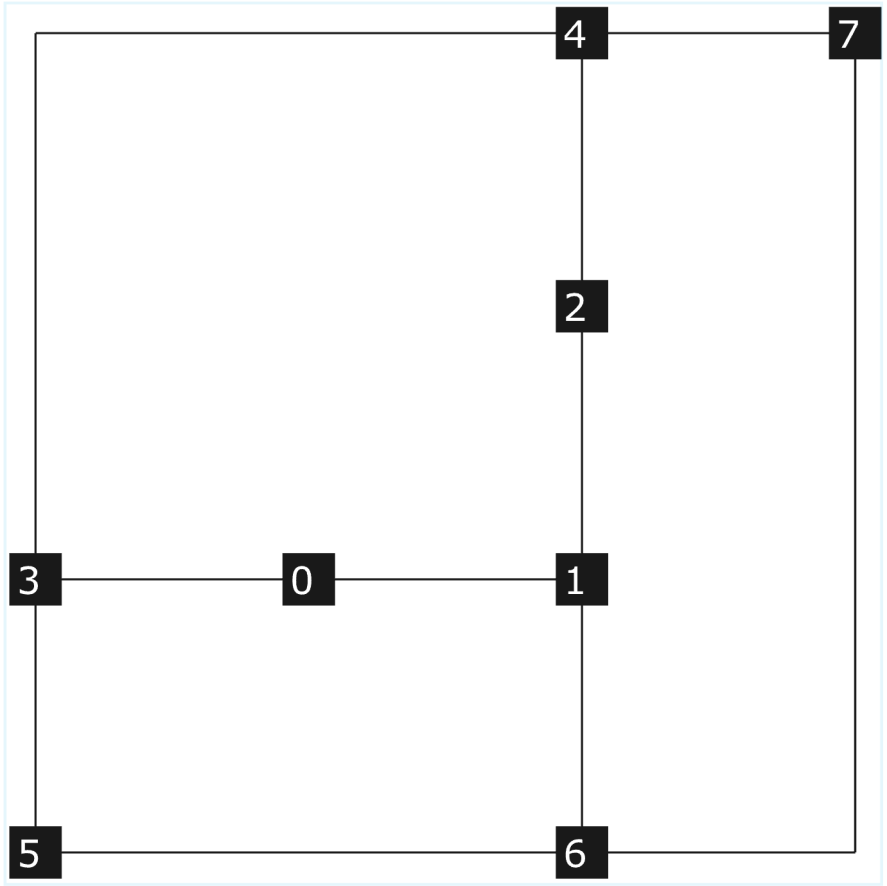
HOLA

they prioritize crossings...

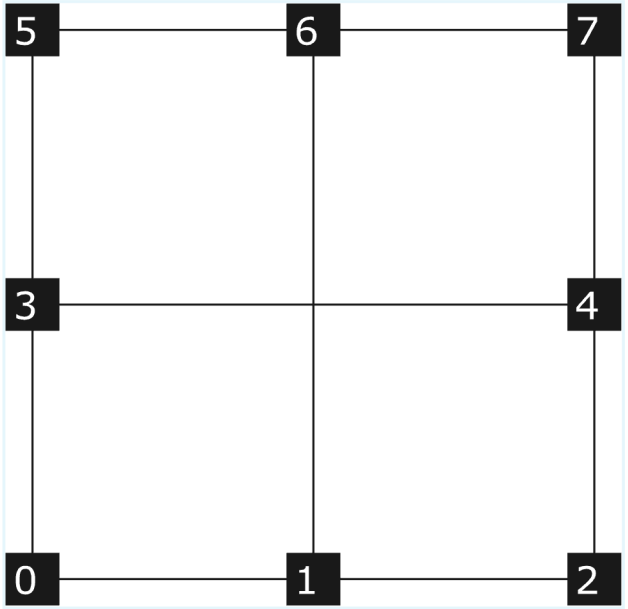


OGDF

...we prioritize bends

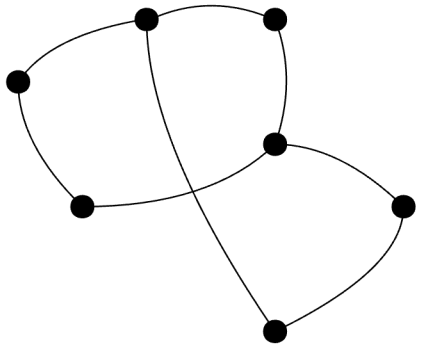


OGDF



DOMUS

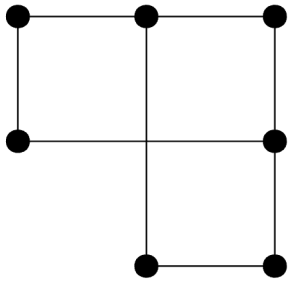
our approach



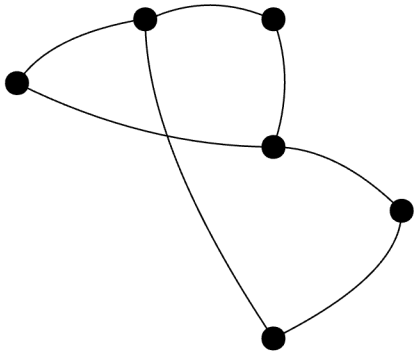
G

find a rectilinear drawing of G

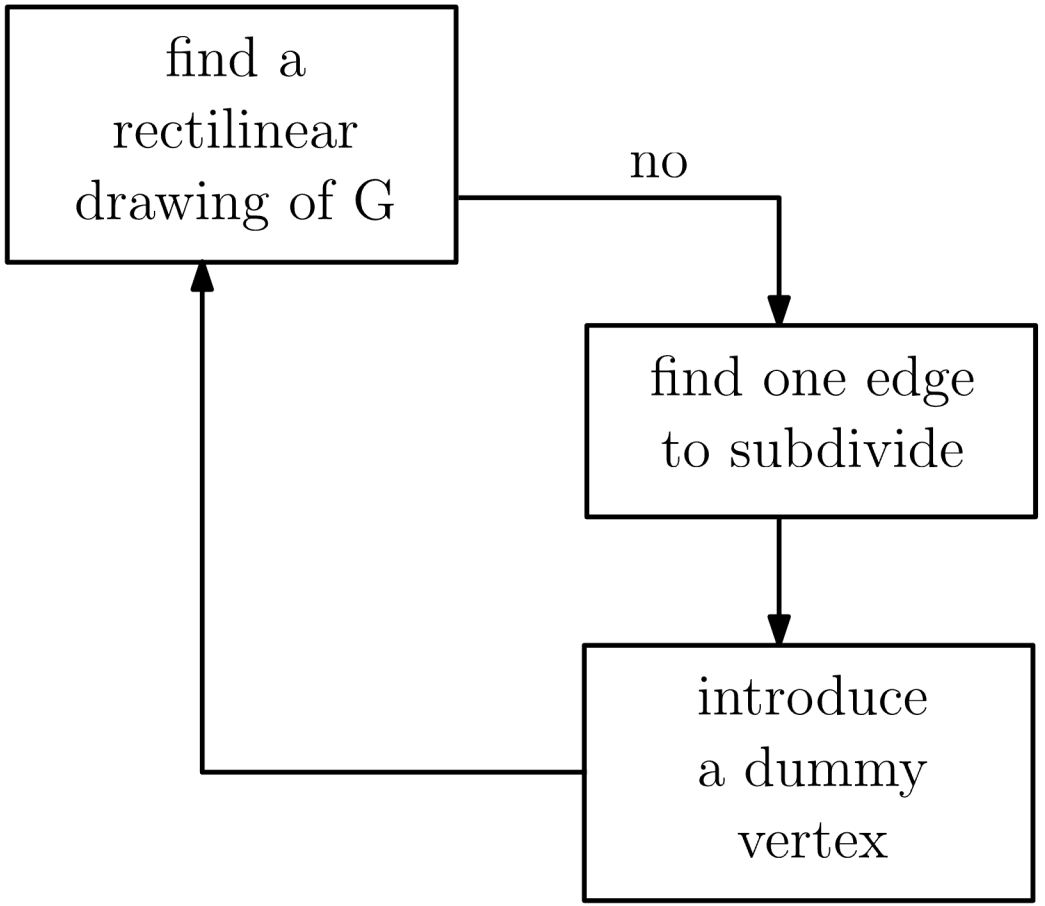
yes



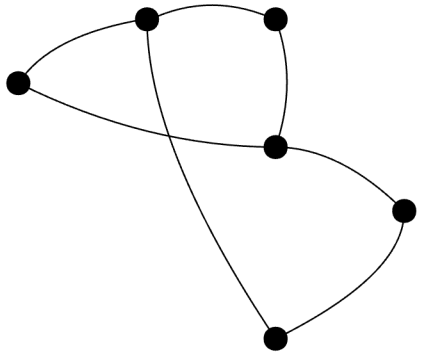
our approach



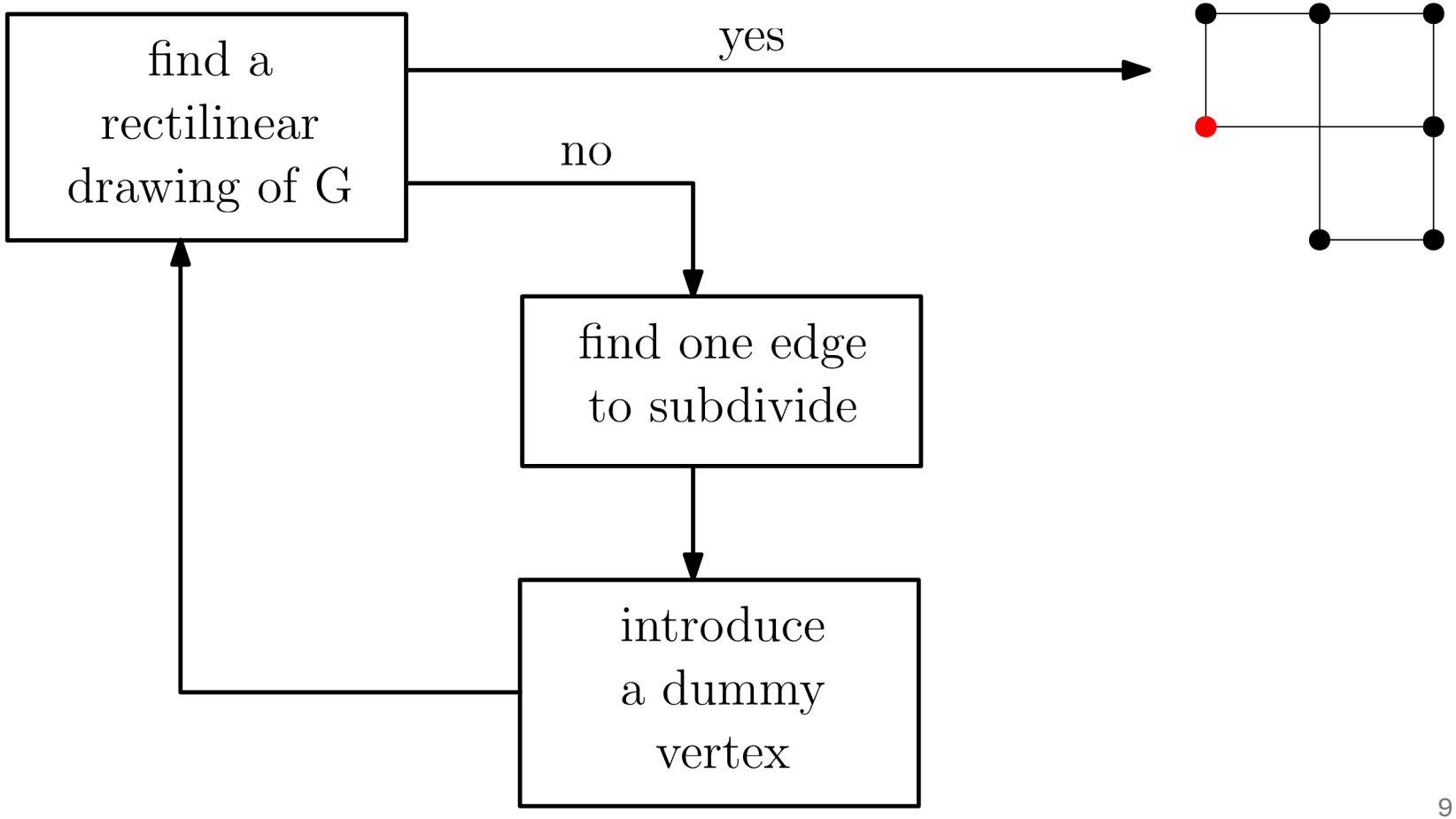
G



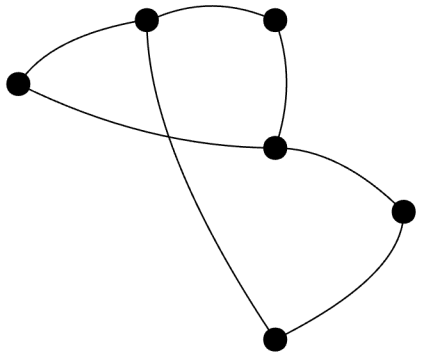
our approach



G



our approach



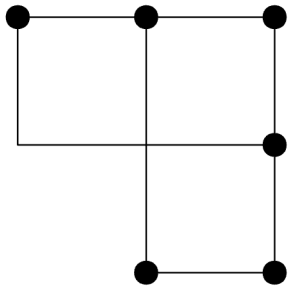
G

NP-complete

?

find a rectilinear drawing of G

yes



no

?

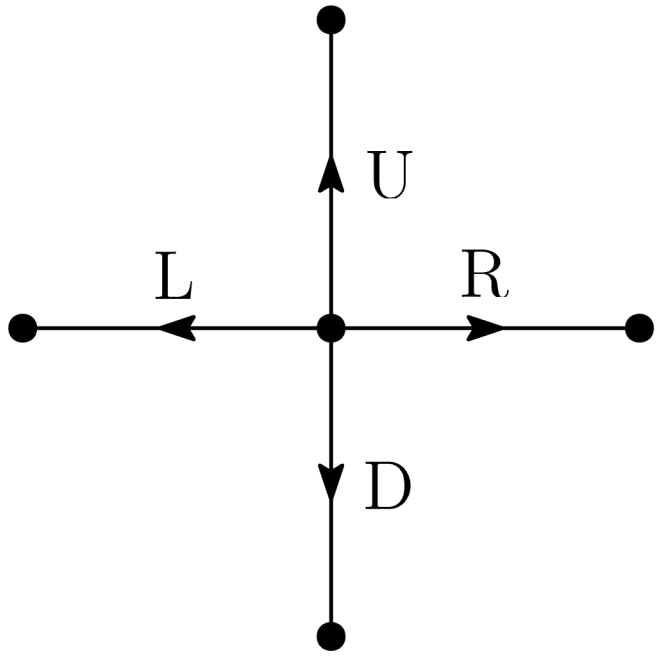
find one edge to subdivide

introduce a dummy vertex

polynomial algorithm for shaped graphs

theorem: given a graph, if each edge has prescribed direction “left”, “right”, “down” or “up”, there exists a polynomial time algorithm that finds a rectilinear drawing of it, if it exists

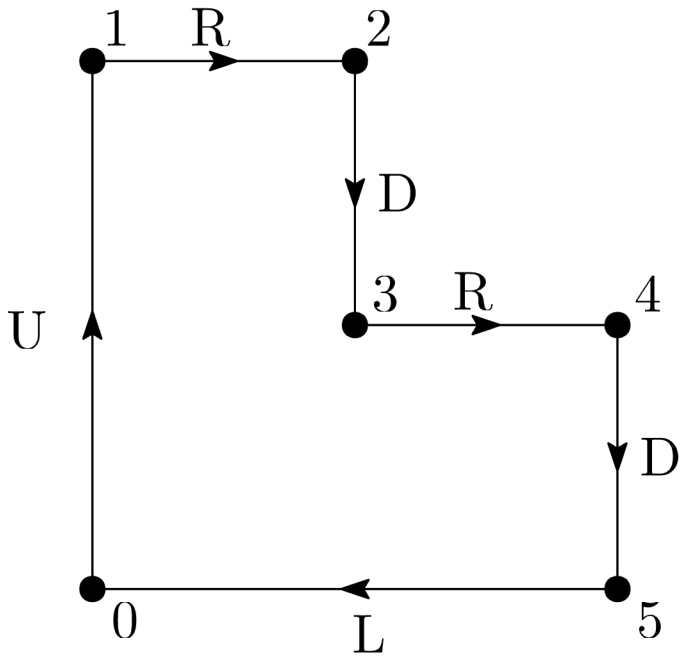
[Manuch, Patterson, Poon, and Thachuk, 2010]



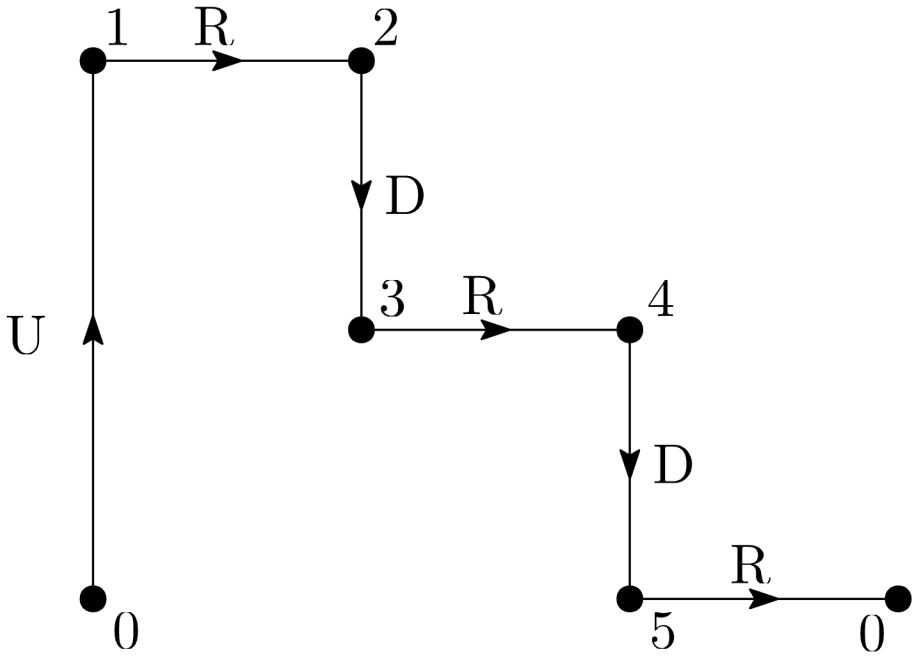
shaped graph

completeness of cycles

definition: a cycle is <u>complete</u> if it contains all the four directions



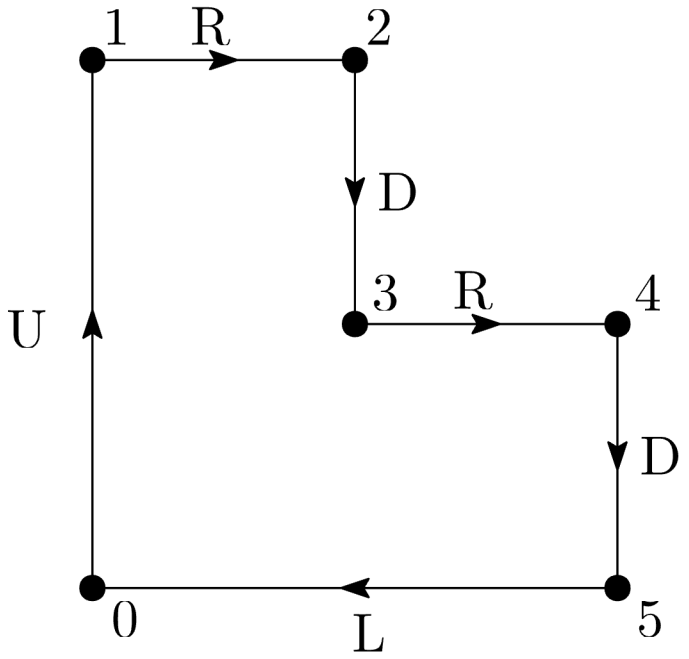
complete cycle



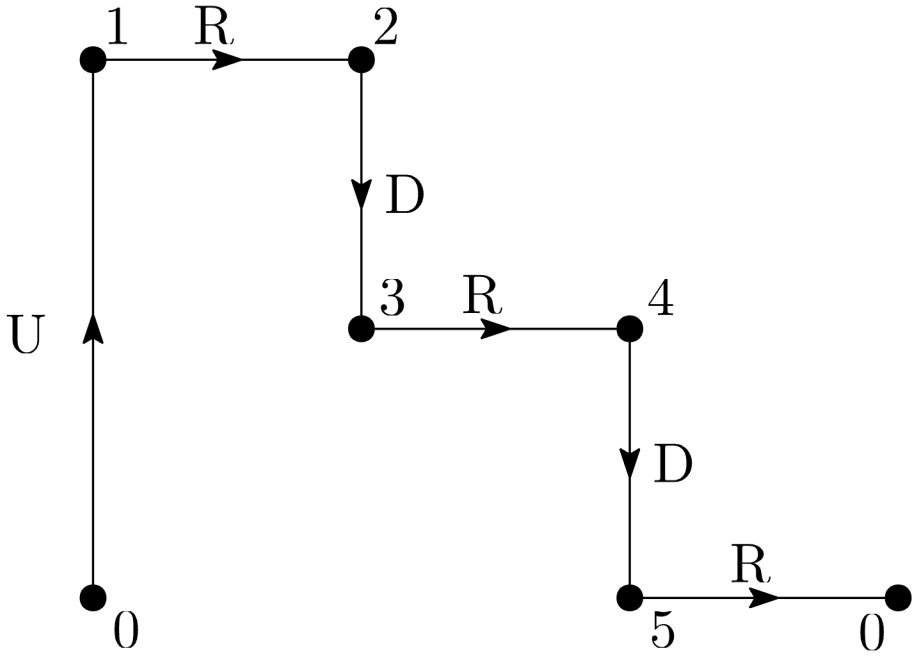
non complete cycle

characterization of rectilinear drawability

theorem: a shaped simple cycle is rectilinear drawable if and only if it is complete



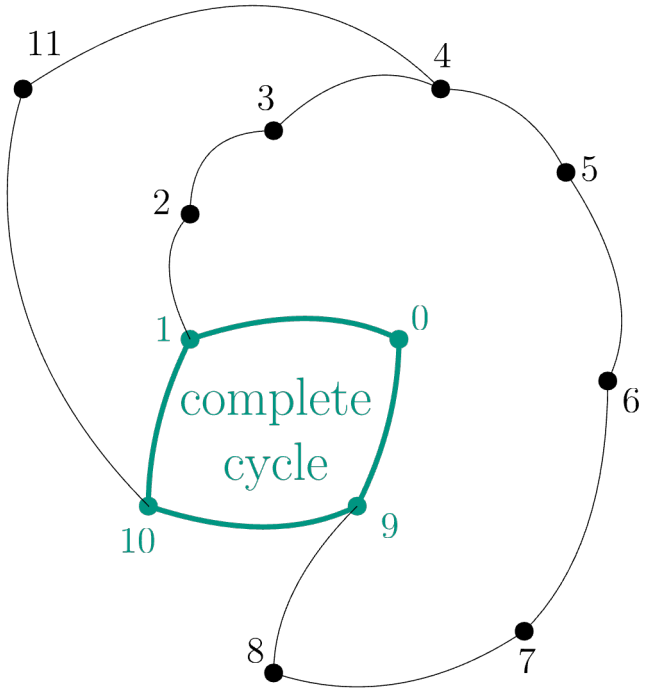
complete cycle

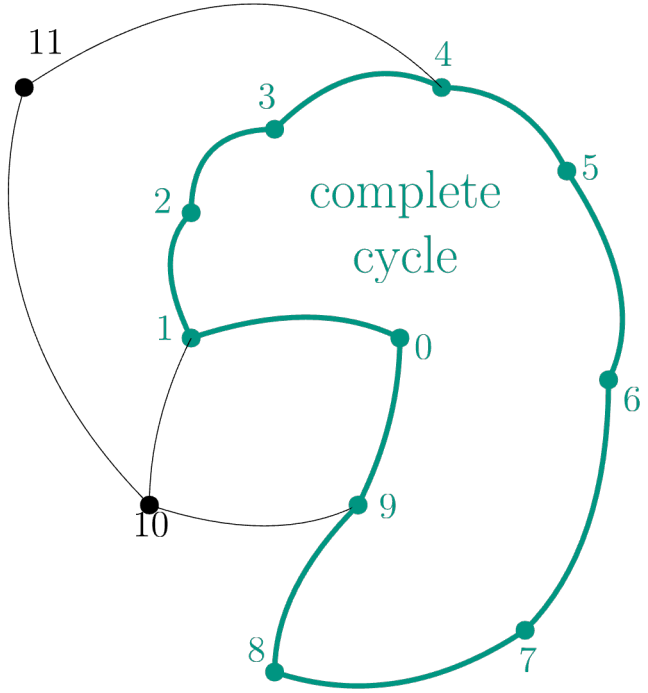


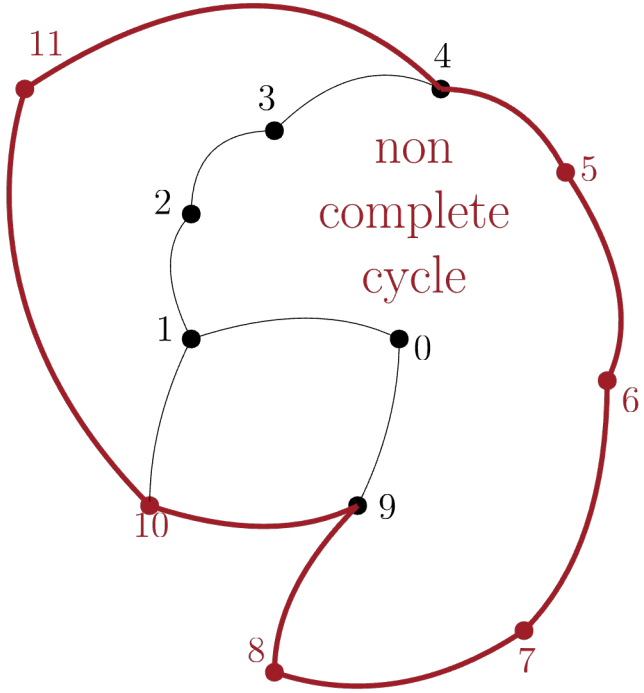
non complete cycle

characterization of rectilinear drawability

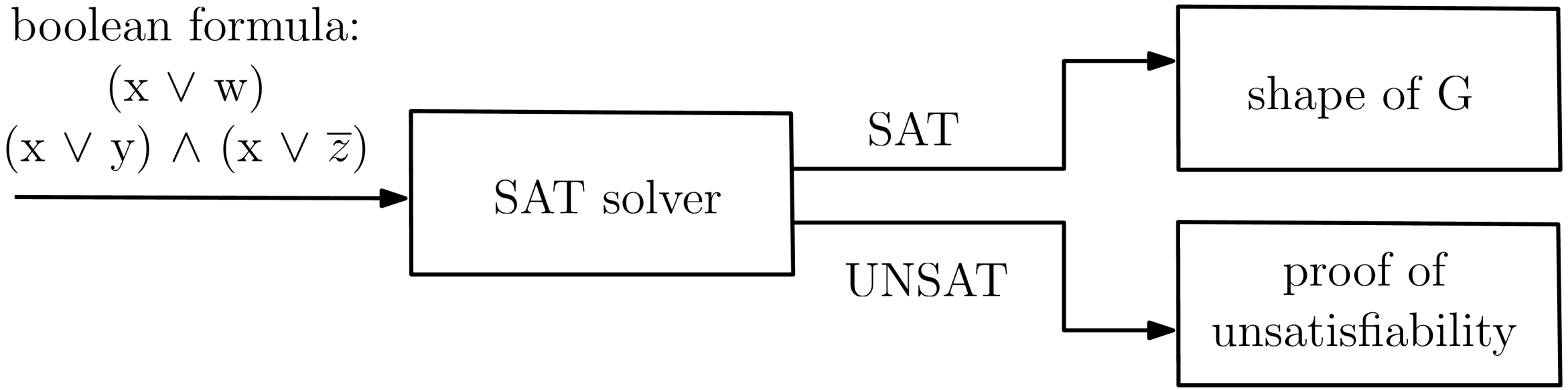
theorem: a shaped graph is rectilinear drawable if and only if all its simple cycles are complete





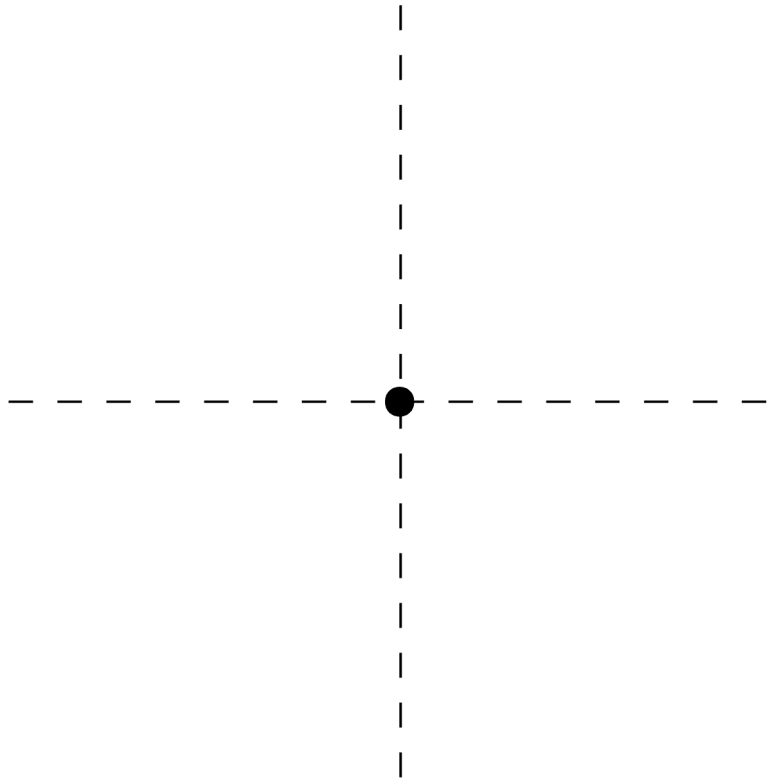


SAT solver for finding a shape



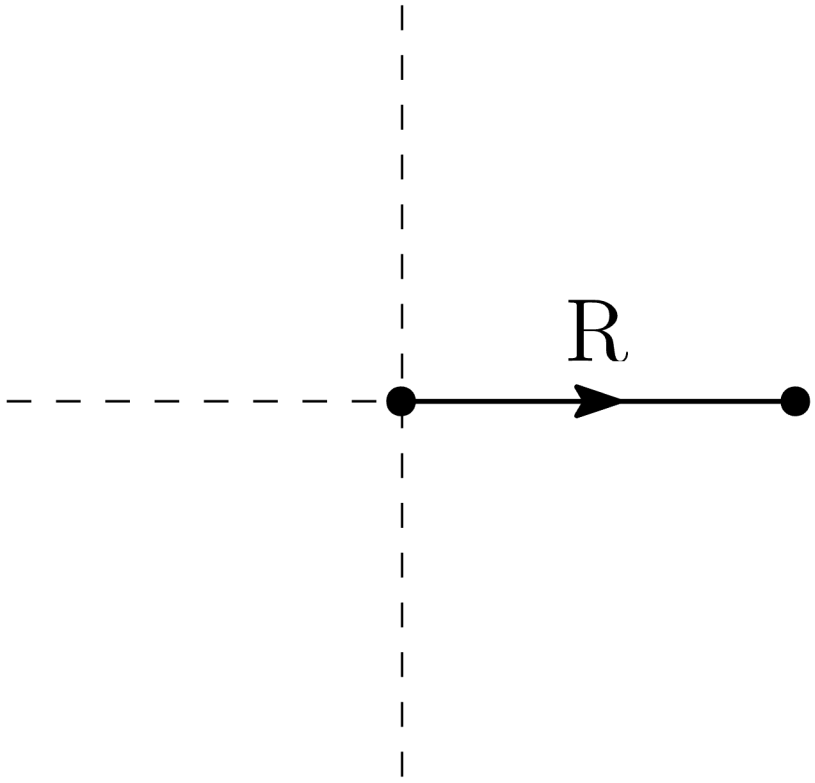
SAT formulation: variables

variable	value
R	False
D	False
U	False
L	False



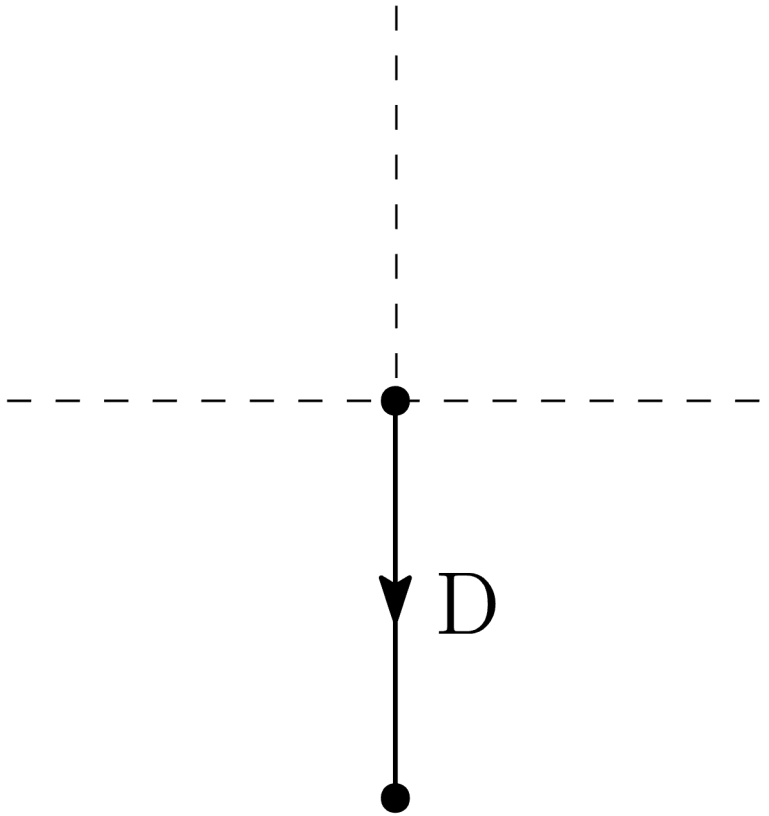
SAT formulation: variables

variable	value
R	True
D	False
U	False
L	False



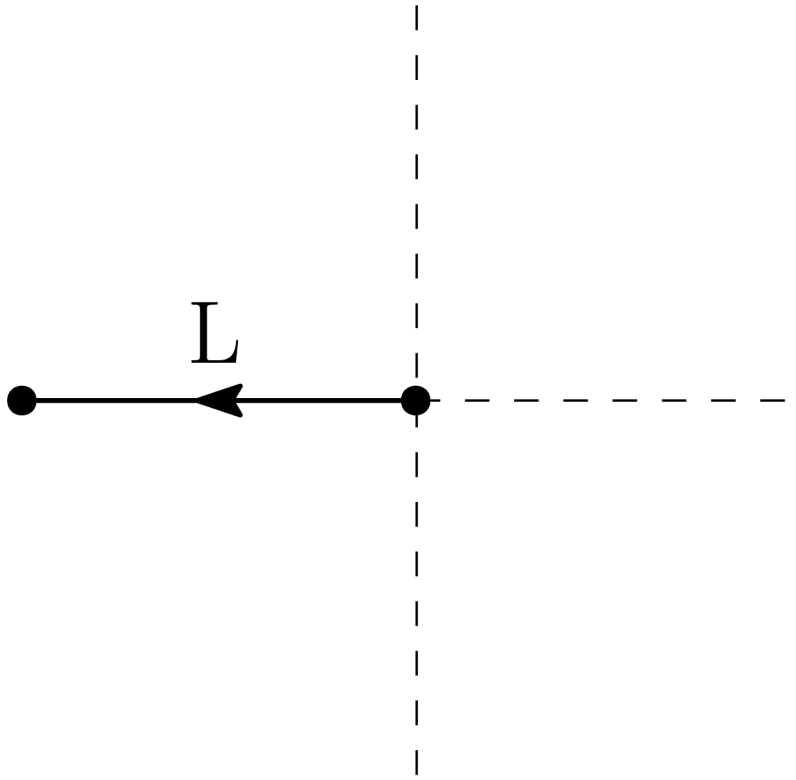
SAT formulation: variables

variable	value
R	False
D	True
U	False
L	False



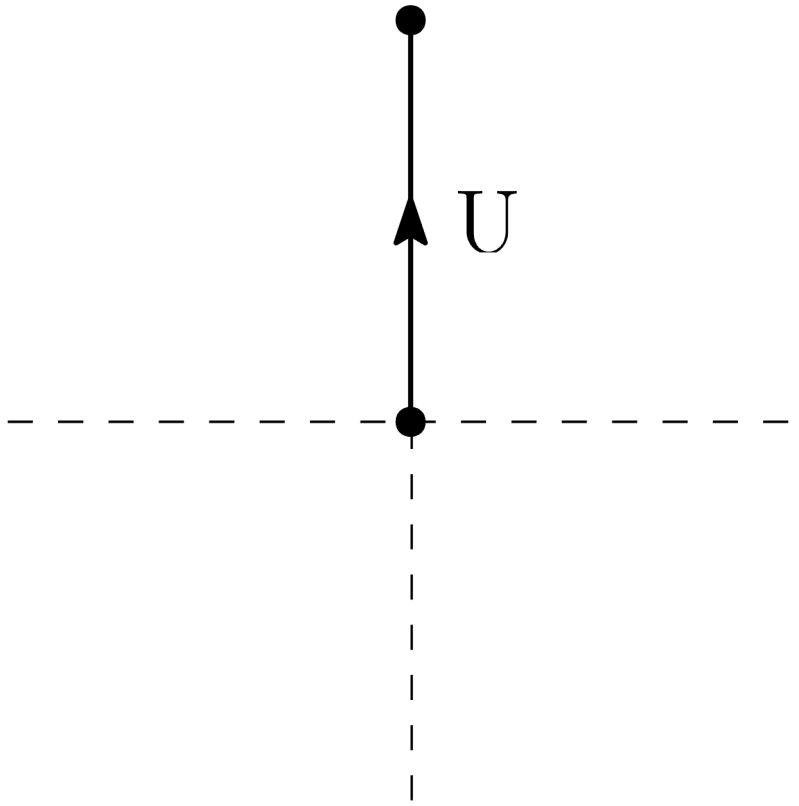
SAT formulation: variables

variable	value
R	False
D	False
U	False
L	True



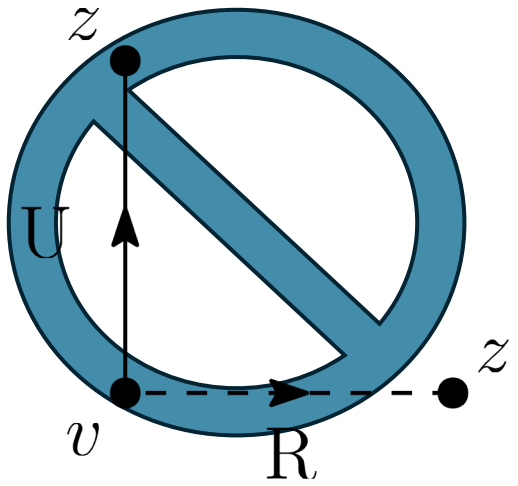
SAT formulation: variables

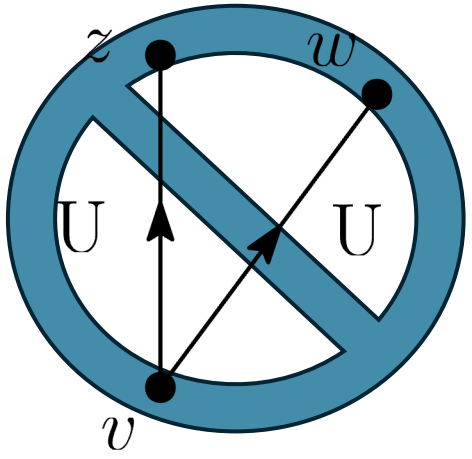
variable	value
R	False
D	False
U	True
L	False

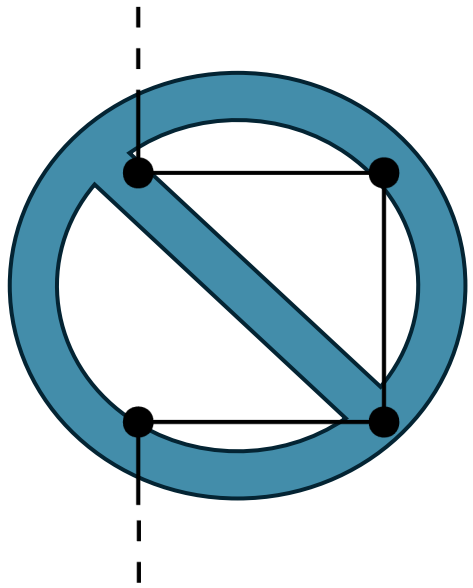


$$\#\text{variables} = 4|E| = O(|V|)$$

SAT formulation: clauses







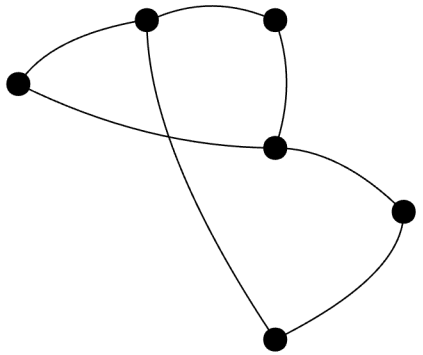
$$\#\text{clauses} = O(|V|)$$

$$\text{clauses length} = O(1)$$

$$\#\text{clauses} = O(|C|)$$

$$\text{clauses length} = O(\text{longest cycle length})$$

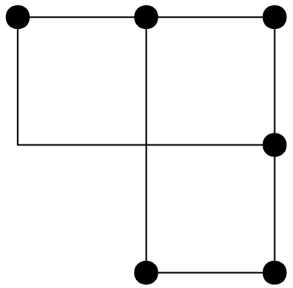
our approach



G

find a rectilinear drawing of G

yes



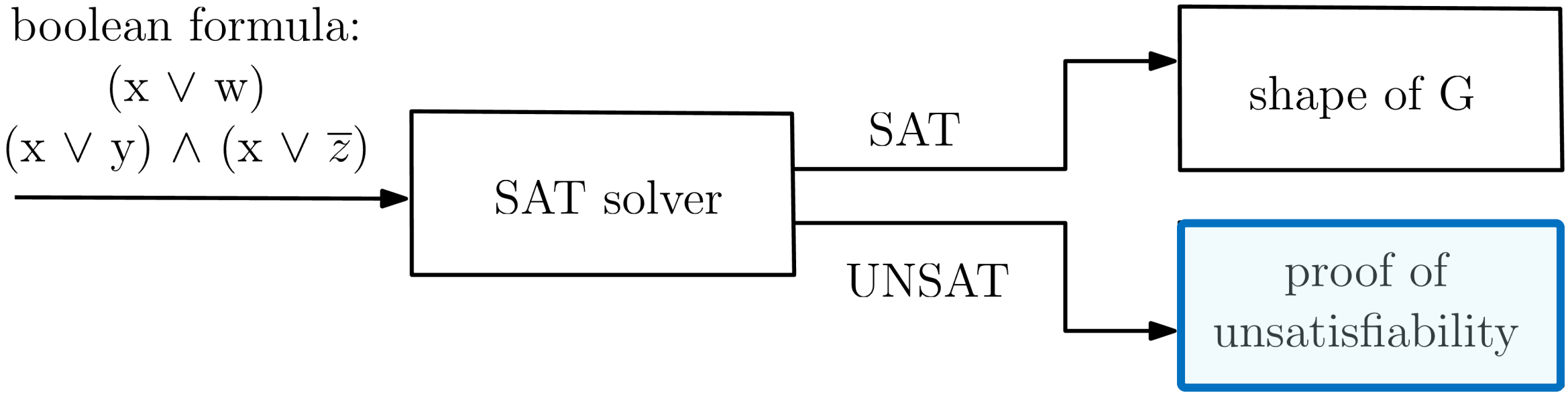
no

?

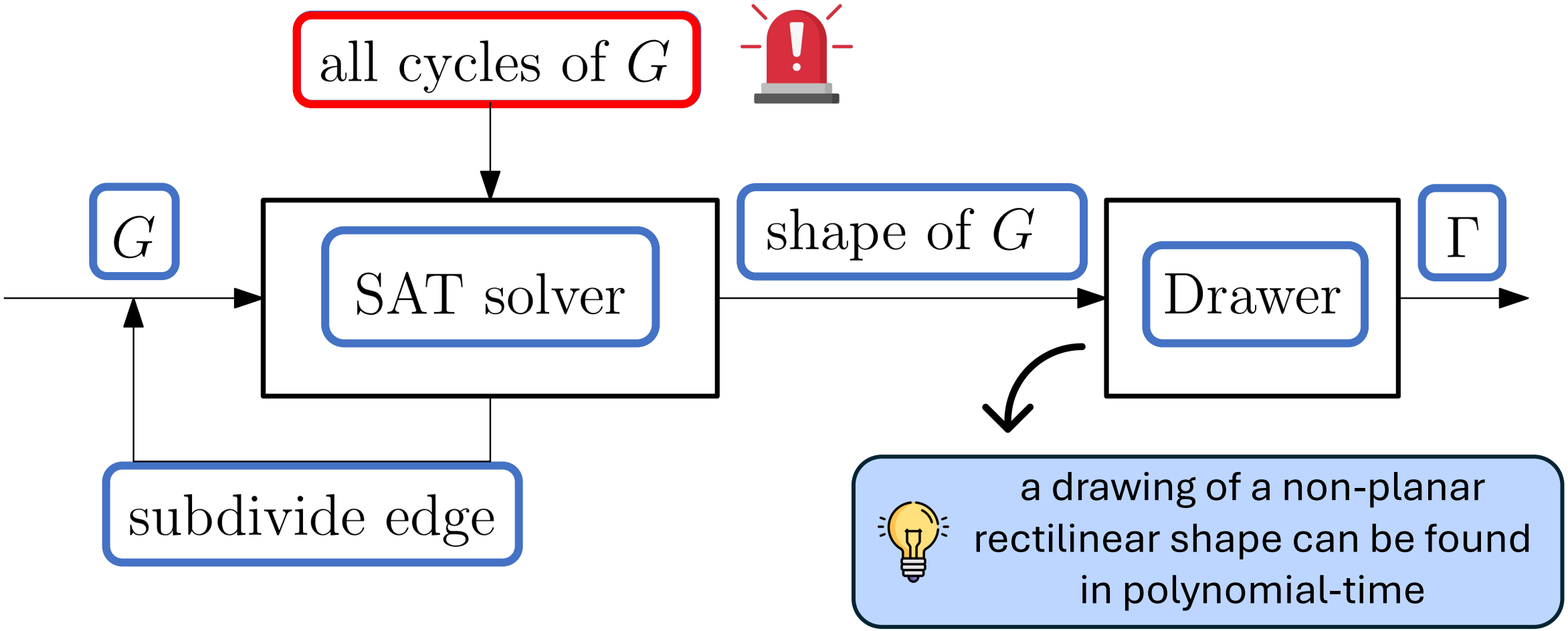
find one edge to subdivide

introduce a dummy vertex

SAT solver for finding a shape

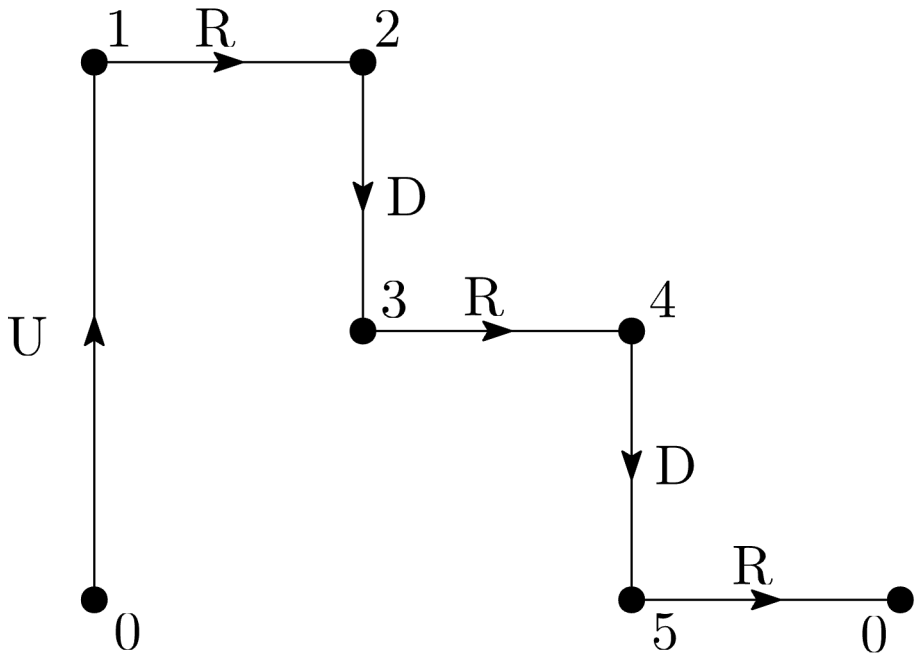


a first framework

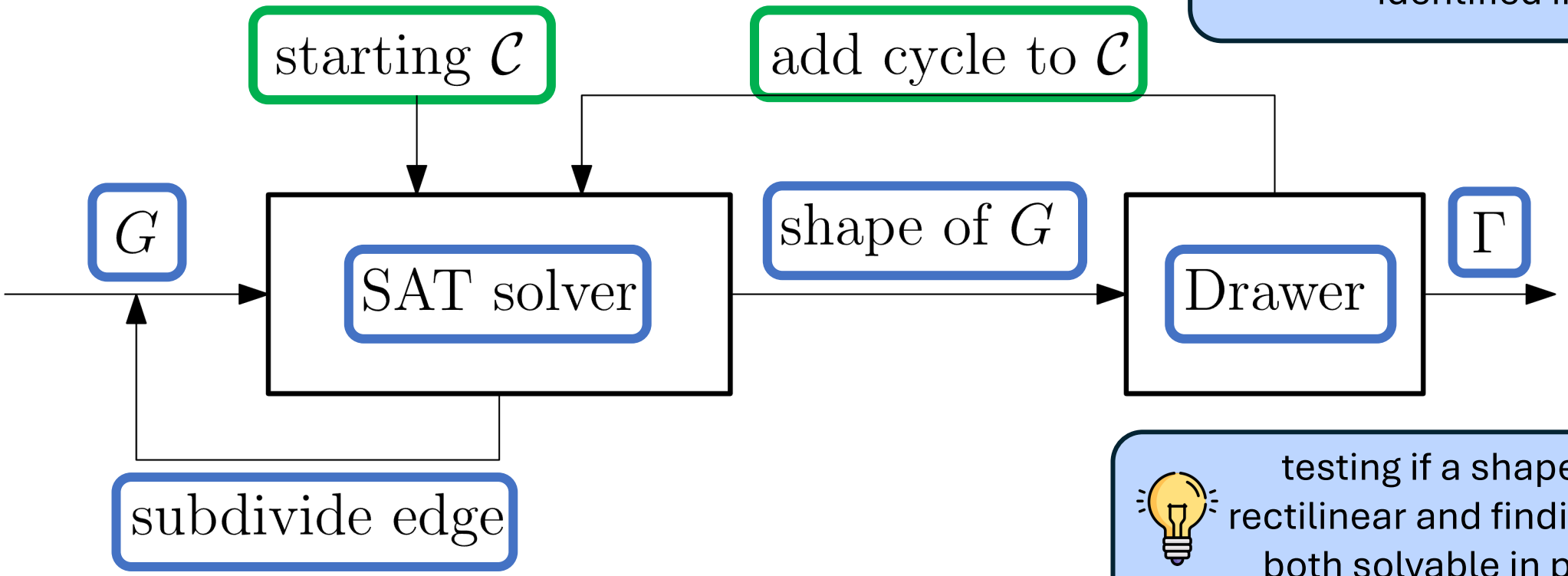


a better approach

theorem: given a shaped graph that is not rectilinear drawable, a non-complete cycle can be identified in linear time



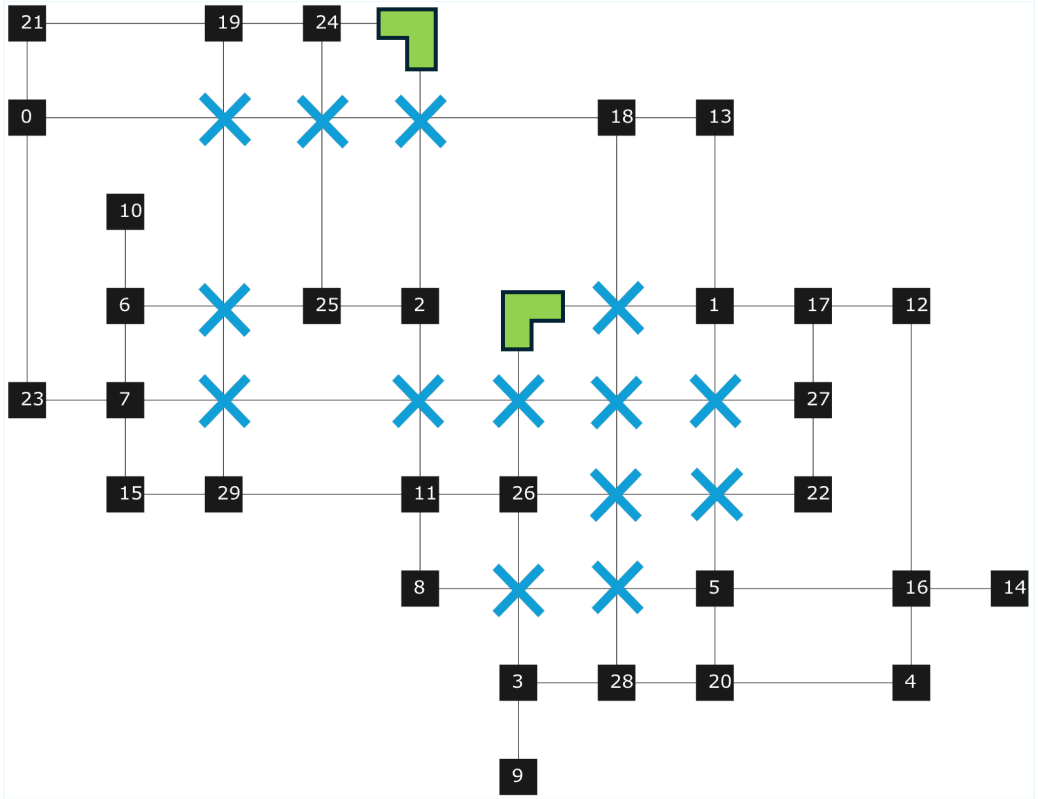
the complete framework



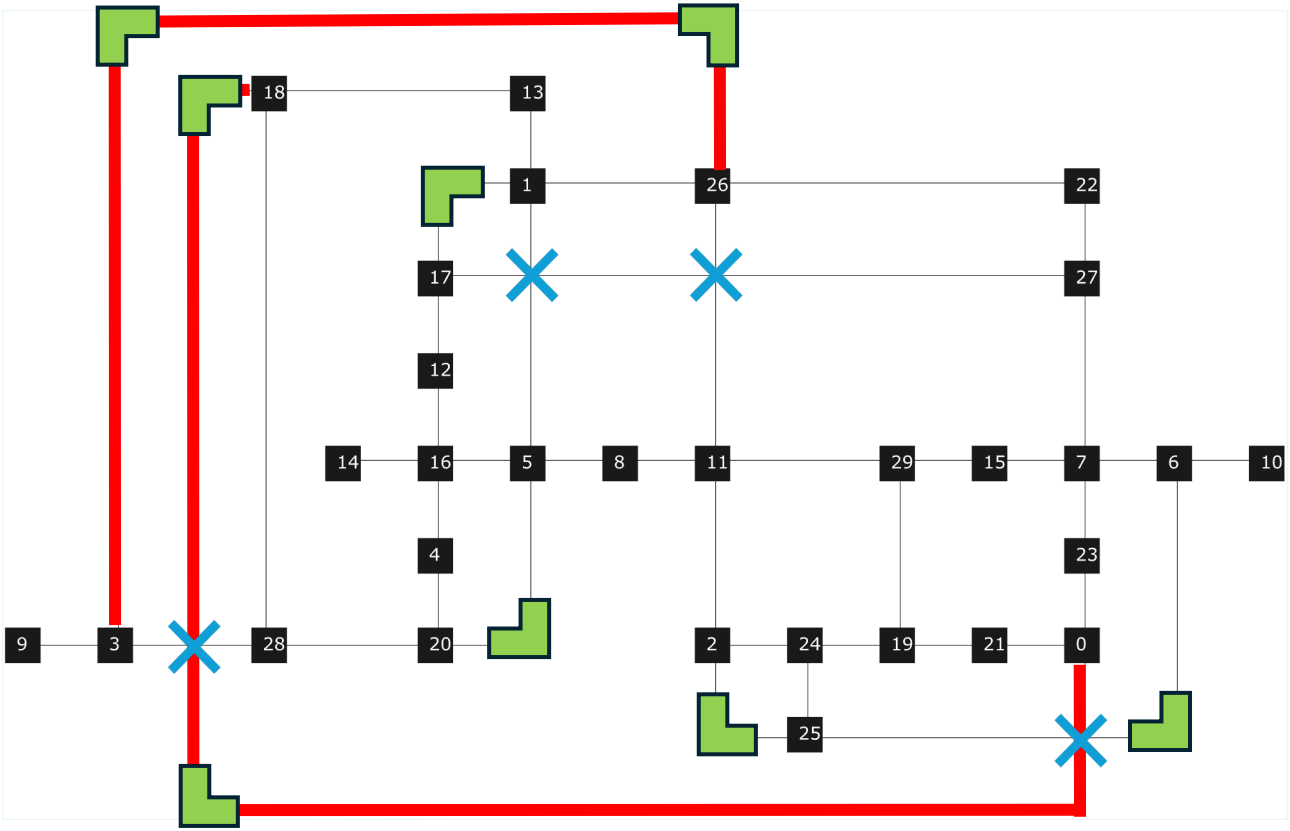
a non-complete cycle in a non-rectilinear shaped graph can be identified in linear time

testing if a shape is non-planar rectilinear and finding its drawing are both solvable in polynomial-time

comparing frameworks

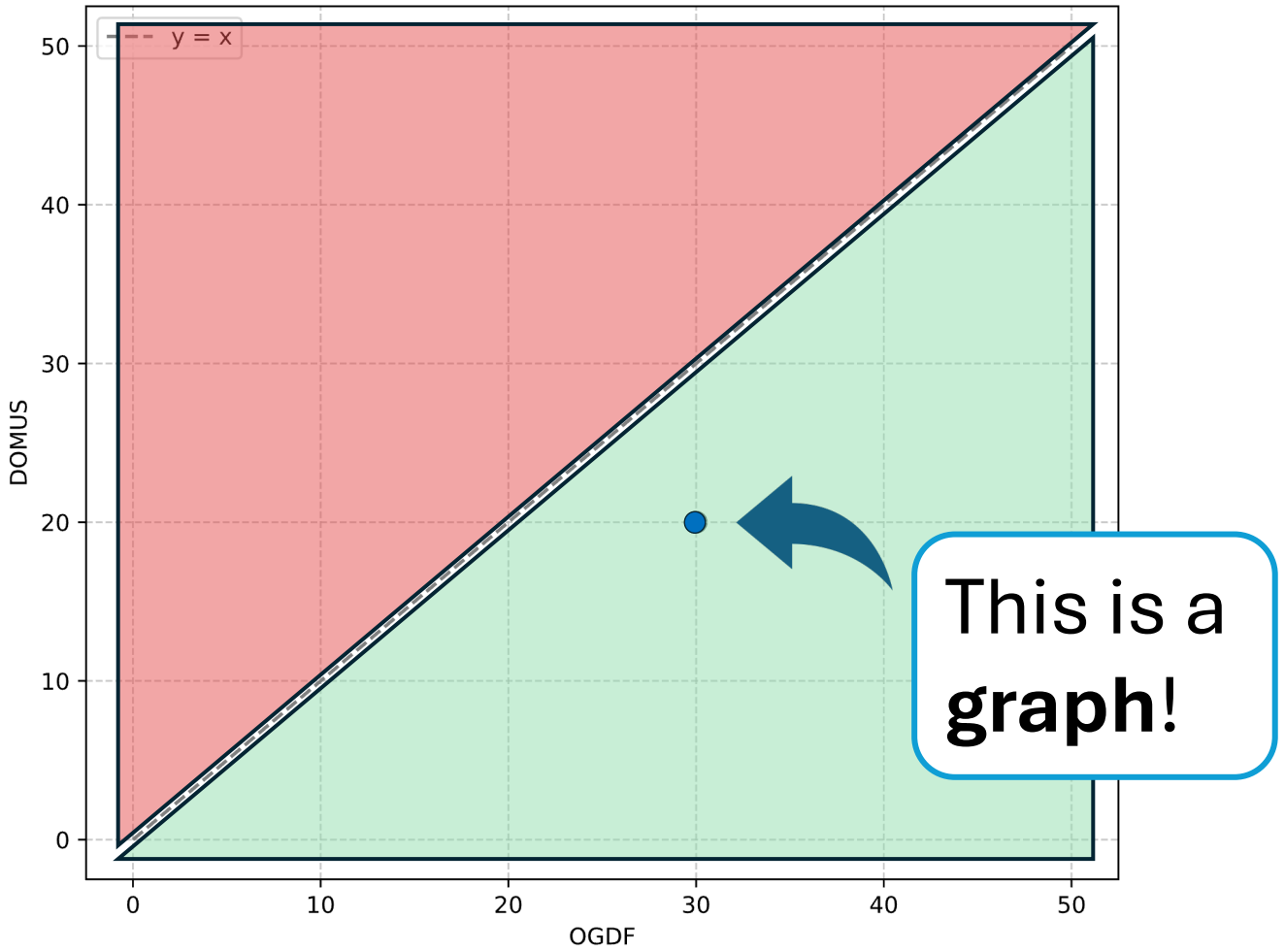


DOMUS

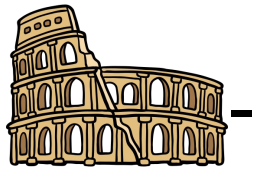


OGDF

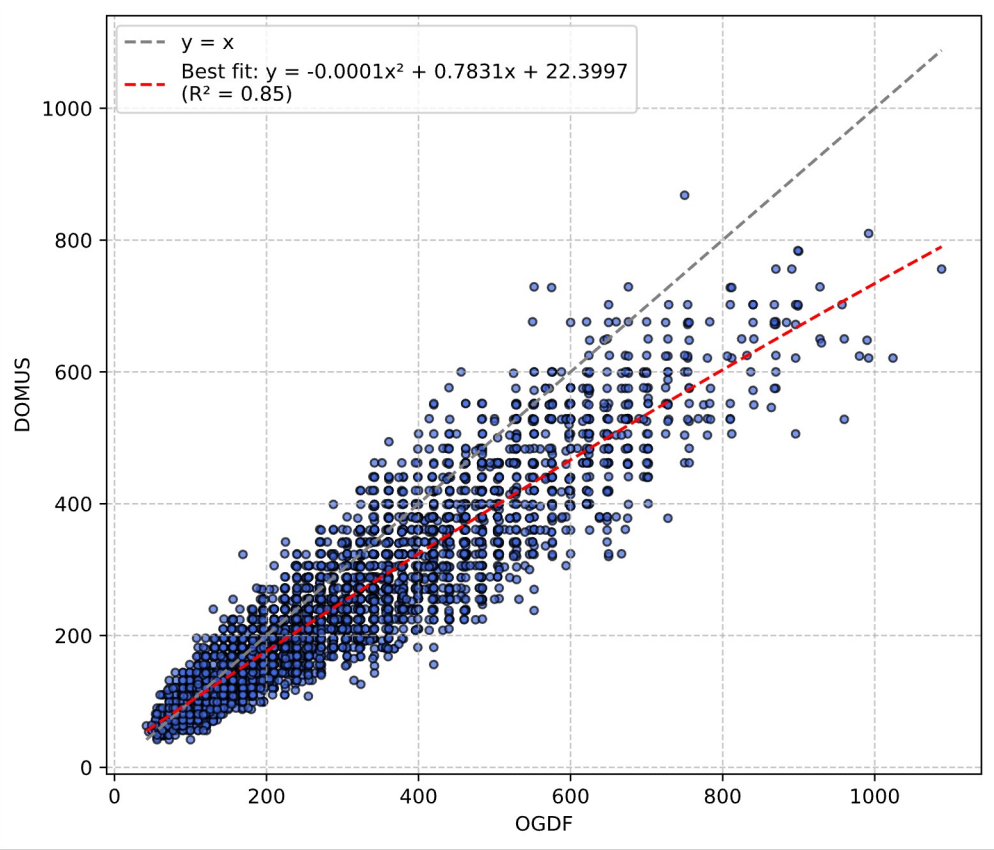
experimental evaluation



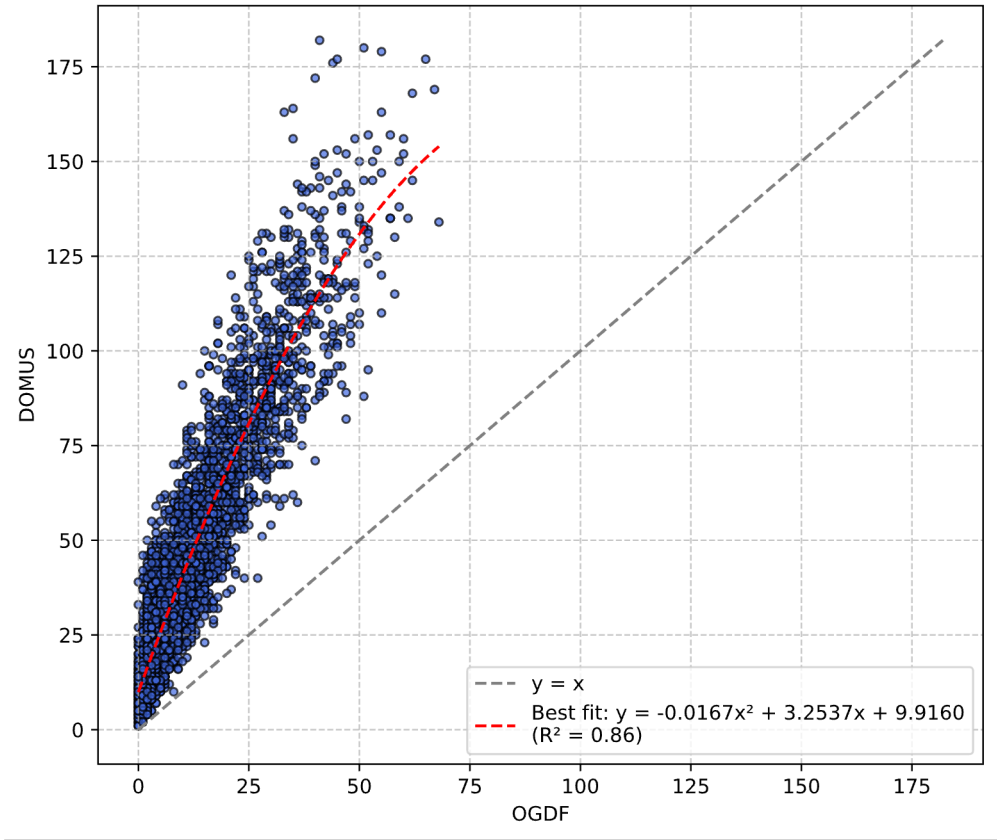
- 4100 graphs
- $|V|$ from 20 to 60
- $|E|/|V|$ from 1.25 to 1.75


-graphs

experimental evaluation

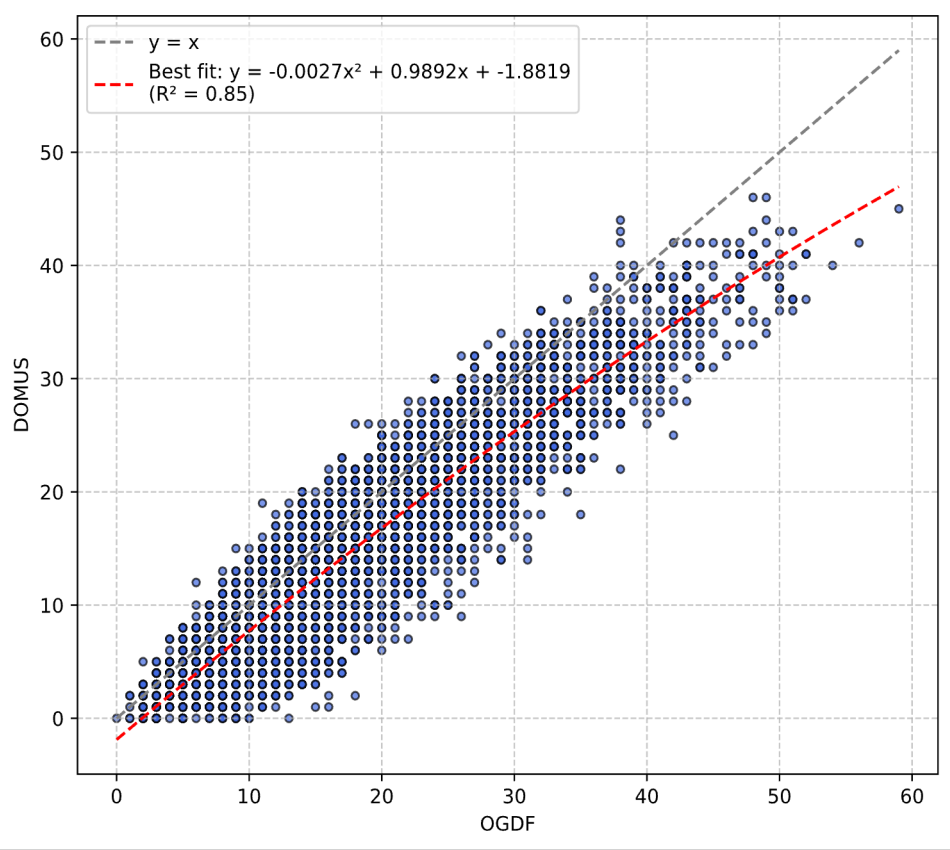


total area

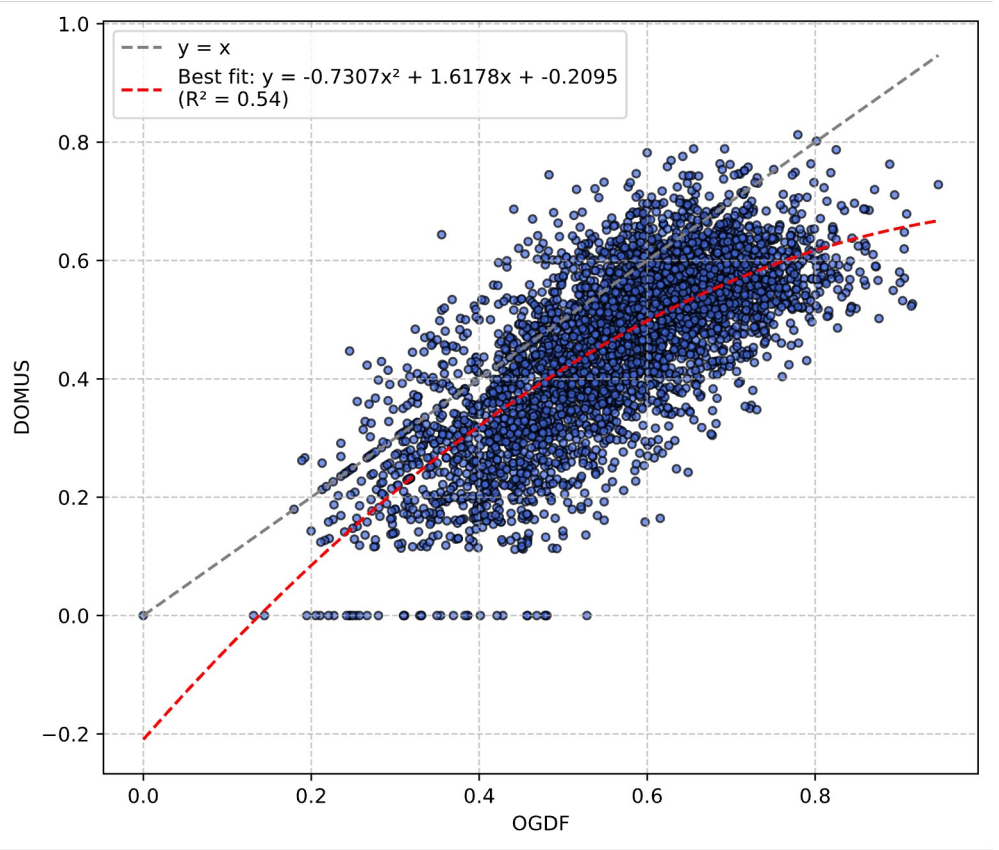


crossings

experimental evaluation

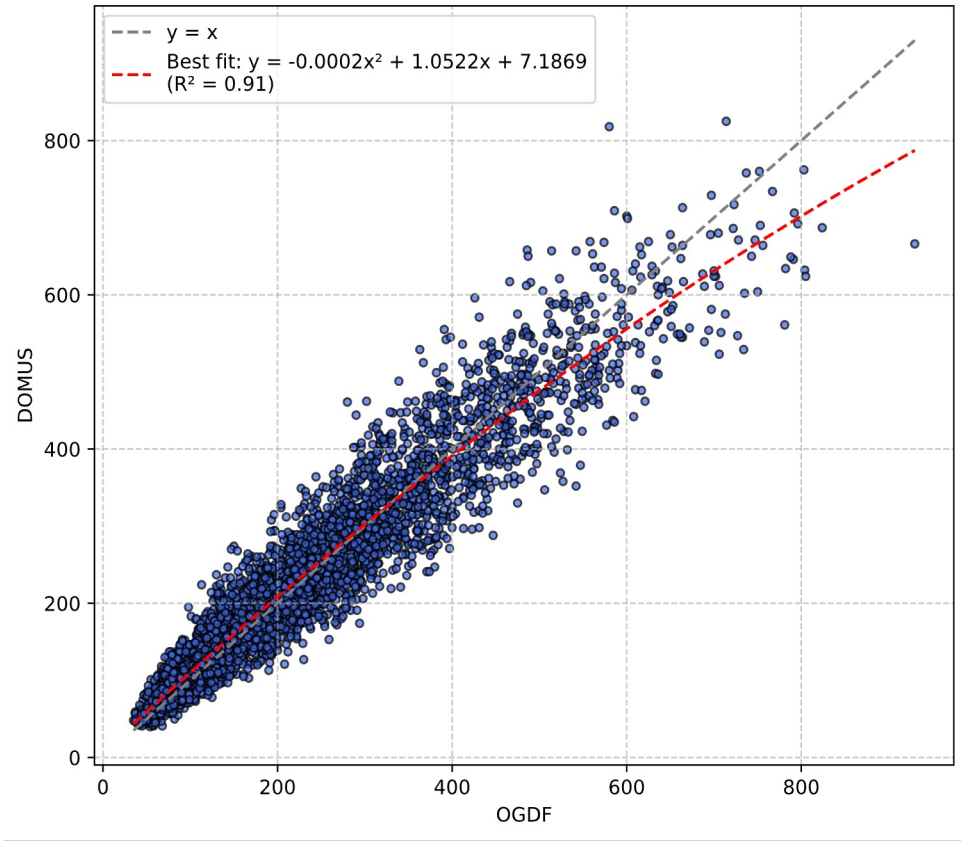


total bends

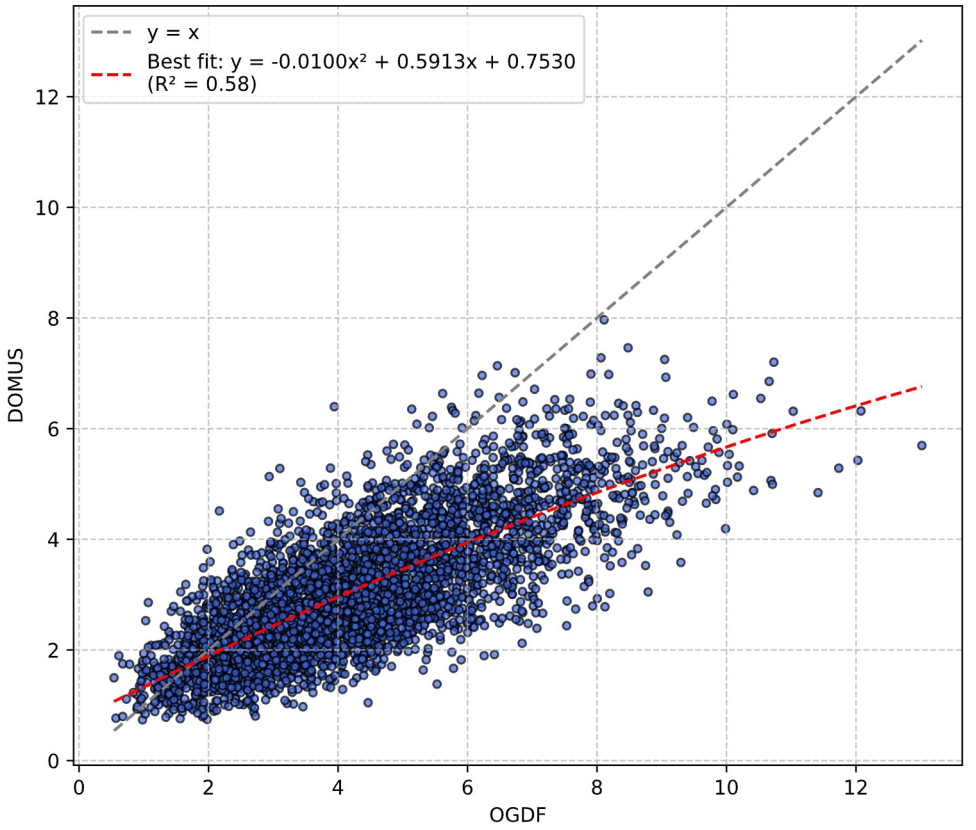


bends std dev

experimental evaluation

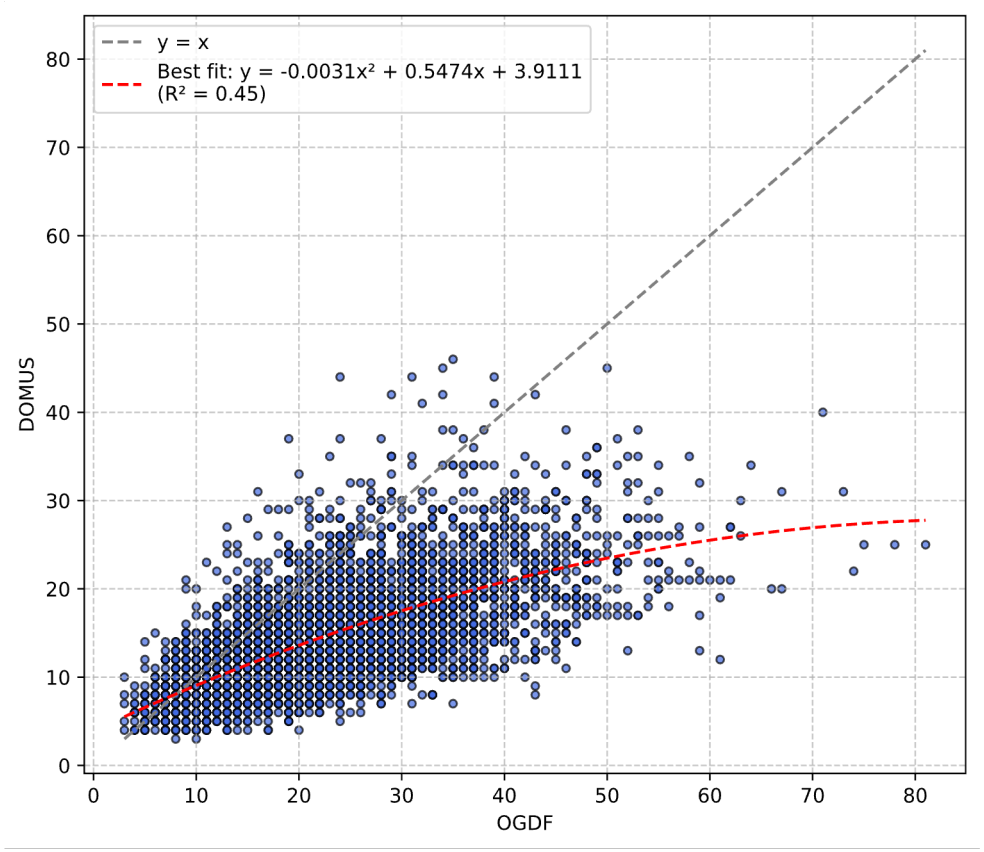


total edge length

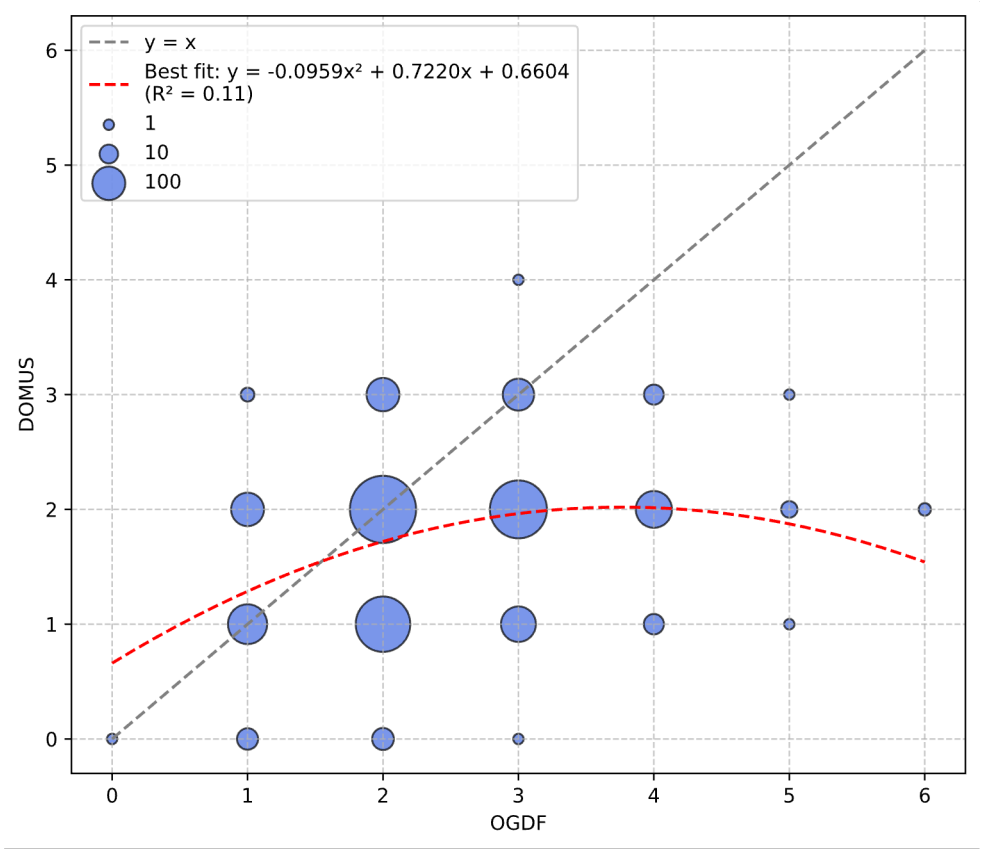


edge length std dev

experimental evaluation

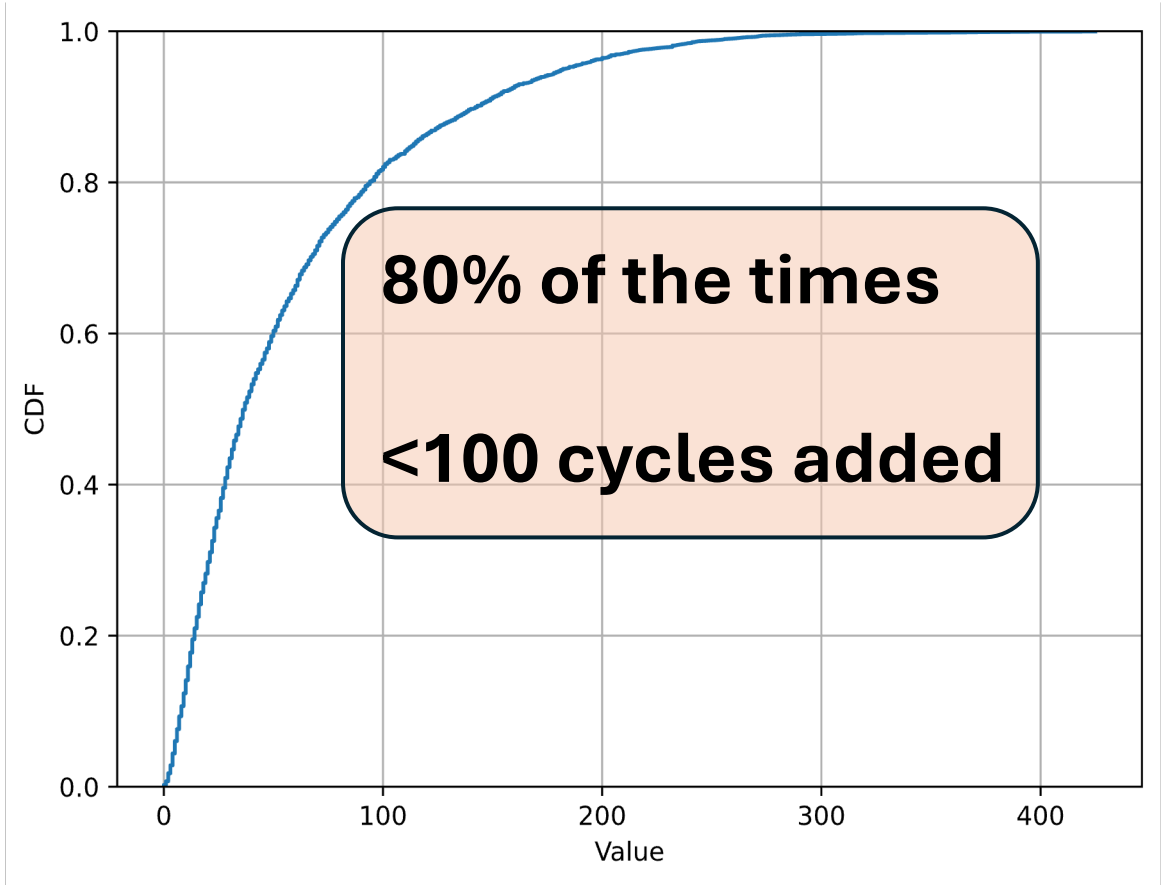


max edge length



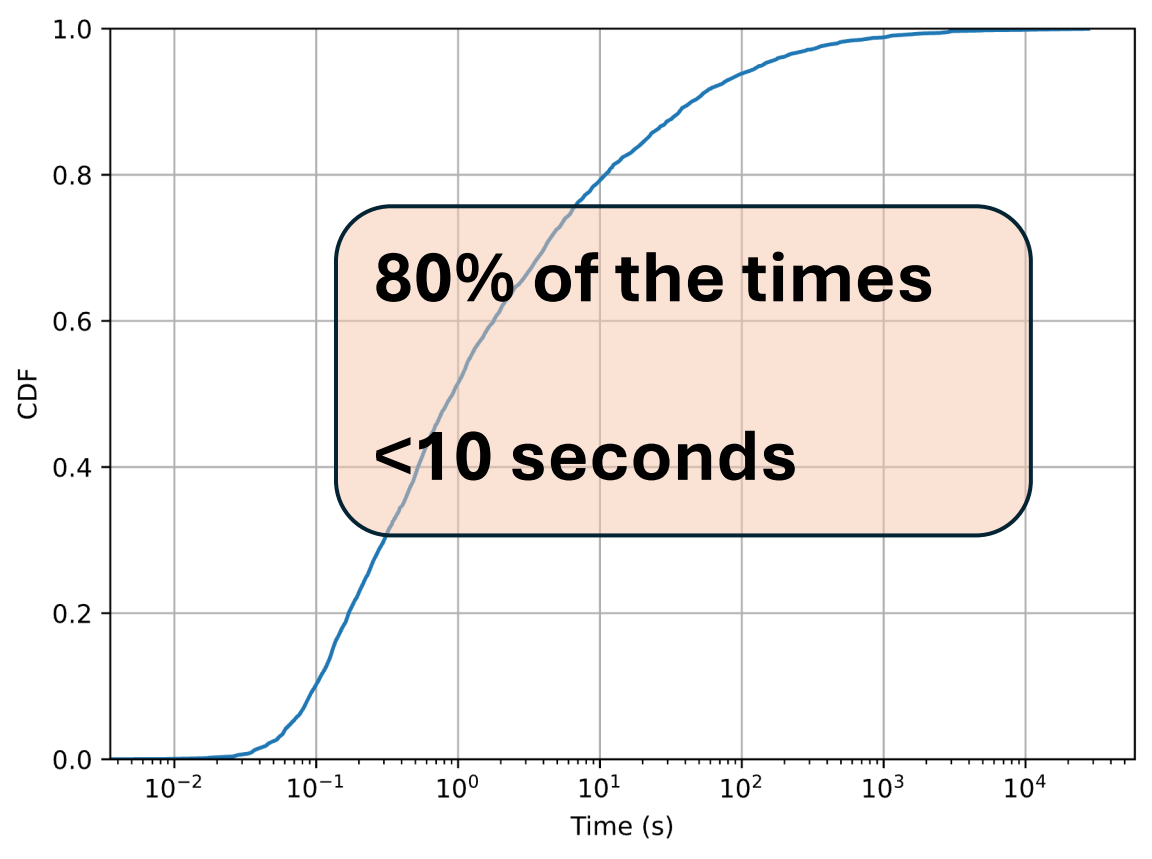
max bends per edge

experimental evaluation



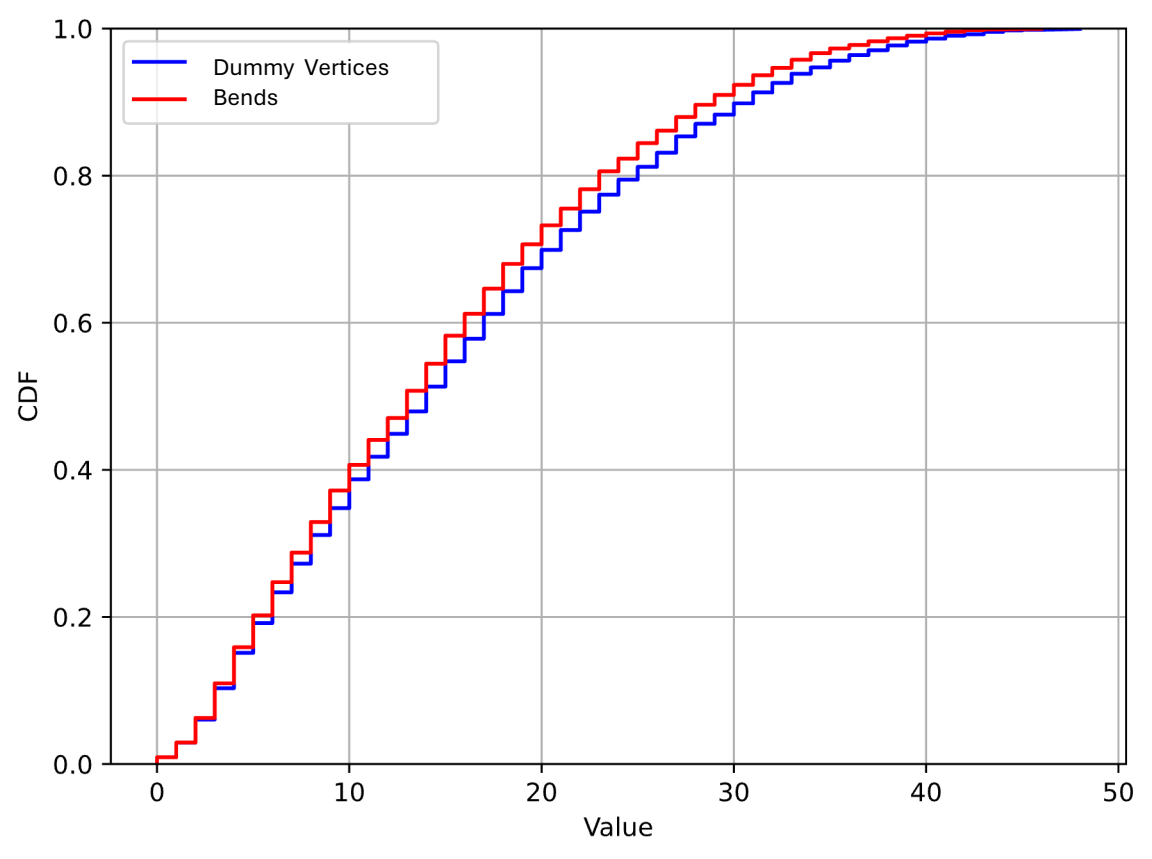
number of added cycles

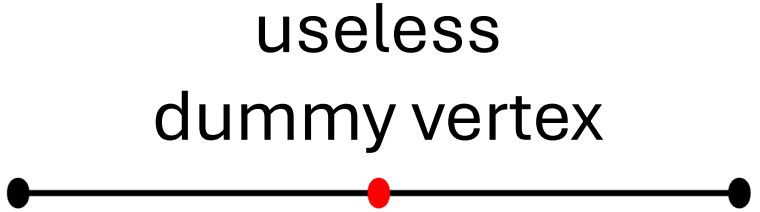
experimental evaluation



total computation time (seconds)

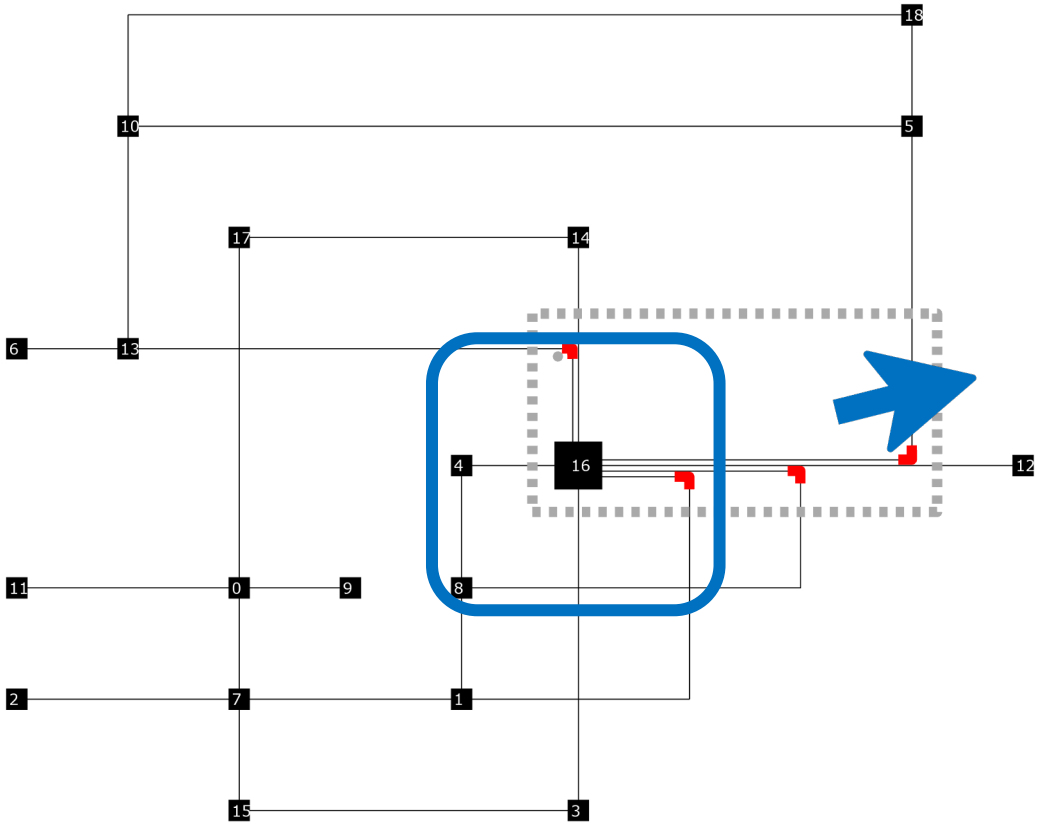
experimental evaluation

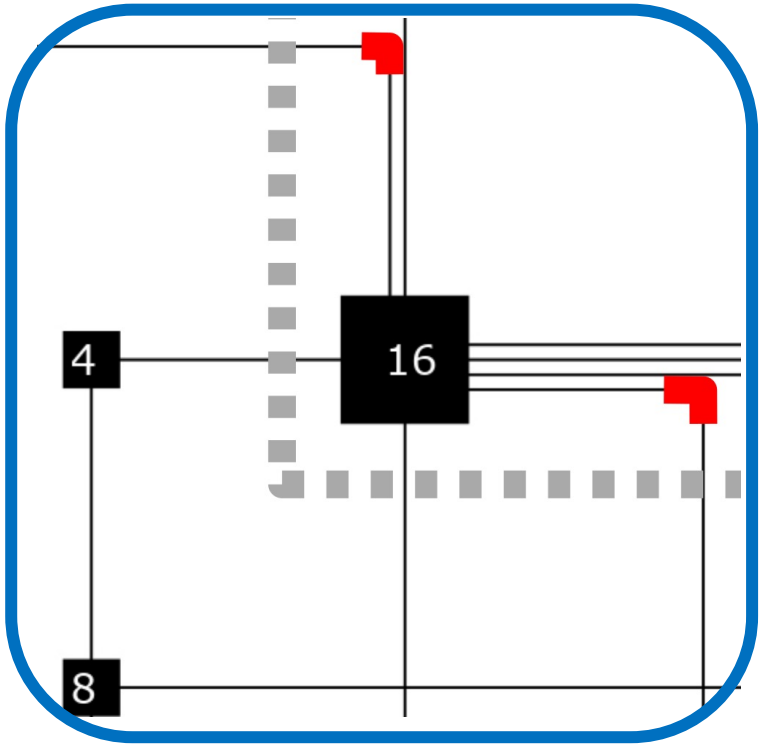




dummy vertices vs bends

generalizing to any graph





conclusions and open problems

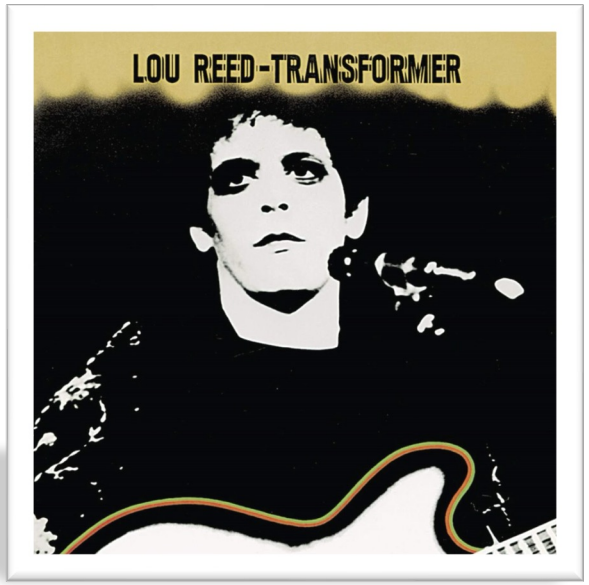
conclusions

- new methodology for orthogonal/rectilinear drawing
- methodology SIMPLE
- good results in most metrics
- constraints can easily be encoded

open problems

- how many cycles to guarantee rectilinear drawability
- encoding crossings in the formulation

A Walk on the Wild Side: a Shape-First Methodology for Orthogonal Drawings



speakers: G. Andreola and A. Strippoli

joint work with: S. Caroppo, G. Di Battista, F. Grosso, and M. Patrignani

Roma Tre