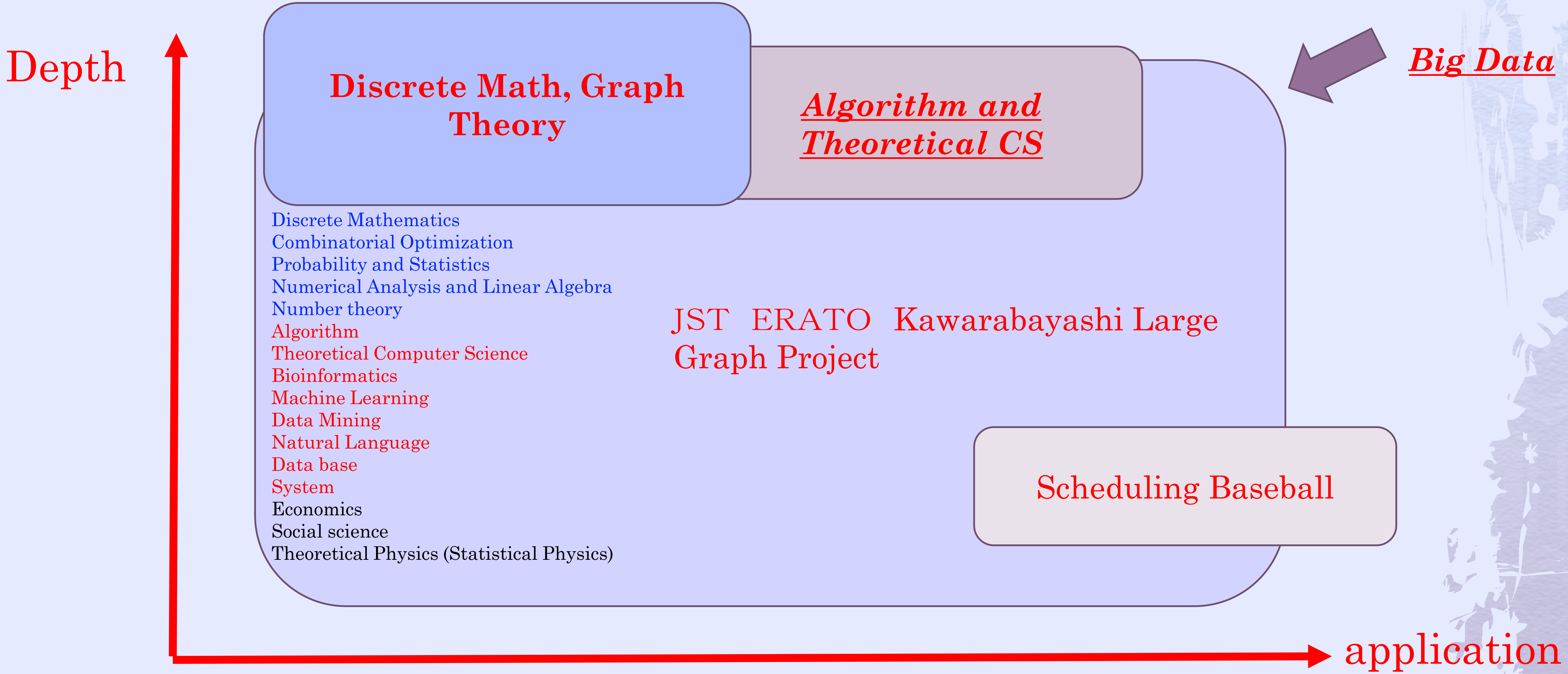
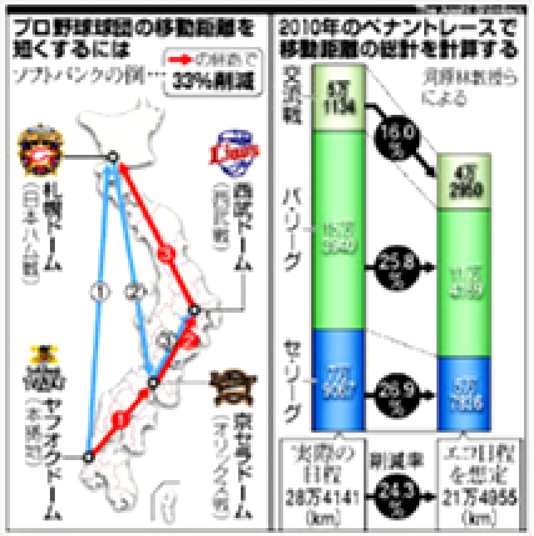
My Research


Depth
Discrete Math, Graph Theory
Algorithm and Theoretical CS
Big Data
Discrete Mathematics
Combinatorial Optimization
Probability and Statistics
Numerical Analysis and Linear Algebra
Number theory
Algorithm
Theoretical Computer Science
Bioinformatics
Machine Learning
Data Mining
Natural Language
Data base
System
Economics
Social science
Theoretical Physics (Statistical Physics)
JST ERATO Kawarabayashi Large Graph Project
Scheduling Baseball
application

プロ野球日程を瞬時に計算　数学者がソフトを開発



プロ野球球団の移動距離を短くする計算例

【藤島真人】1カ月以上かかるプロ野球の日程づくりが、あっという間にできるソフトウエアを数学者が開発した。日程を工夫するだけで、球団の移動距離を2割以上減らすこともできるという。シーズン開幕を控え、彼らの計算式と現実とのギャップはいかに。

開発したのは、国立情報学研究所の河原林健一教授と星野リチャード・前外来研究員。2人は効率の良い鉄道網や電気回路の設計などにも応用できる「グラフ理論」と呼ばれる分野の研究者だ。

ソフト開発は、3年前の3月、カナダからリチャードさんが来日し、たまたま千葉ロッテの本拠地の近くに住んだことがきっかけ。鉄道網のような「グラフ」を球団の移動に置き換え、最適な日程をはじき出せないかを考えた。

［PR］

Graph Theory and Sports Scheduling

Richard Hoshino and Ken-ichi Kawarabayashi

Introduction

The effects of global warming have been well documented, especially in recent years. As a result, the majority of countries have made a commitment to reducing their greenhouse gas emissions, including many whose national governments have made ambitious and unrealistic promises. Meeting these targets will require a coordinated effort from policymakers, businesses, and large industries, and numerous creative solutions will need to be implemented to achieve the desired goal. One potential solution is based on discrete mathematics, where combinatorial and graph-theoretic techniques are applied to scheduling optimization, leading to economic and environmental benefits.

There are many practical roles for mathematically optimal schedules that reduce total travel distance, including supply-chain logistics and airplane flight assignments. In this paper we describe how to optimize the regular-season schedule for ı Professional Baseball (NPB), Japan's most ır professional sports league, with annual es topping one billion U.S. dollars.

ɜn the authors' background as graph theo- ɪis research was motivated by the innocent ɔn of whether NPB scheduling could be converted into a much simpler shortest-path problem. As we describe in this paper, the answer to this question is affirmative. Consequently, we have succeeded in generating the distance-optimal NPB regular-season schedule which retains all of the league's constraints that ensure competitive balance while reducing the total travel distance by 24.3%, or nearly 70,000 kilometers, as compared to the 2010 season schedule.

To solve the NPB scheduling problem, we have generalized and extended the Traveling Tournament Problem (TTP), a well-known topic in sports scheduling [10]. Our research has produced five papers, [4], [5], [6], [7], [8], describing the theoretical aspects of the problem, providing various heuristics for generating distance-optimal intra-league and inter-league schedules, and applying the results to optimize the NPB league schedule.

Shortly after introducing the Traveling Tournament Problem [2], Easton et al. formed a consulting company to develop schedules for professional sports leagues. Their company, the Sports Scheduling Group, has received the contract to produce the regular-season schedule for Major League Baseball in six of the past seven years. Having now completed all of our research on NPB scheduling, our hope is to obtain the contract to produce future NPB regular-season schedules. We are excited by the possibility of sharing our expertise and passion with Nippon Professional Baseball, working in partnership with the league to produce schedules that save money and reduce greenhouse gas emissions, thus making an important contribution to Japan, both economically and environmentally.

Hoshino is a mathematics tutor at Quest University . His email address is `richard.hoshino@questu.`

Kawarabayashi is a professor at the National Insti- nformatics, Japan. His email address is `k_keniti@ .jp.`

p://dx.doi.org/10.1090/noti1010

nakers, businesses, and large industries, and ɔus creative solutions will need to be imple- d to achieve the desired goal. One potential n is based on discrete mathematics, where ıatorial and graph-theoretic techniques are d to scheduling optimization, leading to nic and environmental benefits.
re are many practical roles for mathemat- ɔptimal schedules that reduce total travel ɛe, including supply-chain logistics and air- light assignments. In this paper we describe optimize the regular-season schedule for
to the 2010 season schedule.
To solve the NPB scheduling problem, we have generalized and extended the Traveling Tournament Problem (TTP), a well-known topic in sports scheduling [10]. Our research has produced five papers, [4], [5], [6], [7], [8], describing the theoretical aspects of the problem, providing various heuristics for generating distance-optimal intra-league and inter-league schedules, and applying the results to optimize the NPB league schedule.
Shortly after introducing the Traveling Tournament Problem [2], Easton et al. formed a consulting

STOCとは？

- STOC, FOCS, SODA:　理論計算機科学のトップ会議
- また暗号(Crypto), プライバシー(Privacy), 量子計算量でもベストな結果が発表される！
- しかし実際は, , ,　「難関」数学！
- 誰も実装はしない。実装にはほぼ意味がない。おそらく興味すらない。

→　理論家の論文をそのまま実装してはだめ

- 近年のトレンド:　離散数学, 解析, 確率, 整数論, 幾何, 代数などから, 超「難関」数学の応用と拡張が中心
- 数学のビッグネームの参入: Terry Tao, Tim Gowers, Laszlo Lovasz, Lex Schrijver, Noga Alon, Endre Szemeredi, Assaf Naor, Yuval Peres, Jeff Cheeger, Bruce Kelner…(フィルーズ賞, アーベル賞, あるいはアーベル賞候補者)

Refine by AUTHOR

- Avi Wigderson (91)
- Noga Alon (75)
- Piotr Indyk (67)
- Frank Thomson Leighton (67)
- Christos H. Papadimitriou (65)
- Baruch Awerbuch (59)
- Robert Endre Tarjan (59)
- Mikkel Thorup (59)
- Venkatesan Guruswami (57)
- Sanjeev Khanna (57)
- Uri Zwick (55)
- Santosh Vempala (55)
- Anupam Gupta (55)
- Micha Sharir (55)
- Madhu Sudan (54)
- Moni Naor (54)
- Moses Charikar (53)
- Joseph Naor (53)
- Russell Impagliazzo (50)
- Oded Goldreich (49)
- Rafail Ostrovsky (49)
- Alan M. Frieze (49)
- Jon M. Kleinberg (48)
- Yuval Rabani (48)
- Uriel Feige (48)
- Éva Tardos (47)
- Ken-ichi Kawarabayashi (46)
- Zvi Galil (46)
- Ran Raz (45)

理論の世界： STOC, FOCS, SODA世界

チューリング賞受賞者や，ネバンリンナ賞受賞が，
大量にいる世界　＋　未来のチューリング賞受賞候補が
たくさんいる世界（おそらくチューリング賞を最も輩出している分野）
過去30年のチューリング賞受賞者

Richard Karp (1985), Hopcroft and Tarjan (1986),
Juris Hartmanis and Richard E. Stearns(1993),
Mauel Blum(1995), Andrew Yao(2000), Rivest, Shamir,
Adleman(2002), Leslie Valiant(2010), Micali, Goldwasser(2012)

ネバンリンナ賞
Tarjan(82), Valiant(86), Razborov(90), Wigderson(94), Shor(98)
Sudan(02), Kleinberg(06), Spielman(10), Khot(14)

ユダヤ人が半数以上！
Non－US, Non-Israel： Mikkel Thorup, Ken-ichi Kawarabayashi
Under 40: Venkastesan Guruswami, Anupam Gupta
Ken-ichi Kawarabayashi

Refine by AUTHOR

Avi Wigderson (91)
Noga Alon (75)
Piotr Indyk (67)
Frank Thomson Leighton (67)
Christos H. Papadimitriou (65)
Baruch Awerbuch (59)
Robert Endre Tarjan (59)
Mikkel Thorup (59)
Venkatesan Guruswami (57)
Sanjeev Khanna (57)
Uri Zwick (55)
Santosh Vempala (55)
Anupam Gupta (55)
Micha Sharir (55)
Madhu Sudan (54)
Moni Naor (54)
Moses Charikar (53)
Joseph Naor (53)
Russell Impagliazzo (50)
Oded Goldreich (49)
Rafail Ostrovsky (49)
Alan M. Frieze (49)
Jon M. Kleinberg (48)
Yuval Rabani (48)
Uriel Feige (48)
Éva Tardos (47)
Ken-ichi Kawarabayashi (46)
Zvi Galil (46)
Ran Raz (45)

理論研究の世界： STOC, FOCS, SODA世界

ここで生き残るのは結構つらい！
→ 理論屋さんだけでやっていくのは結構つらいよ！
→ でも他の分野でも活躍できる！

でも… 数学なのに、評価される理由
1. 実用面での貢献をした研究者も多い
2. 理論が強い学生は、常に優良物件！
3. 他分野にも影響を与える研究者も多い！

Alon： アーベル賞を10年以内にとりそうな数学者
Leighton： Akamaiの創始者
Kleinberg. . .
Piotr Indyk： ICML'15 ベストペーパー
Ragahavan: Former Y! research director
S. Muthukrishnan: Databaseでもビッグネーム
Motowani：Brin, PageのPDメンター
C. Dvorak： Privacyでの超有名人
その他： 理論研究者が他分野で、論文をたくさん発表！

MY STOC PAPERS

1. Ken-ichi Kawarabayashi, Mikkel Thorup
Deterministic Global Minimum Cut of a Simple Graph in Near-linear Time

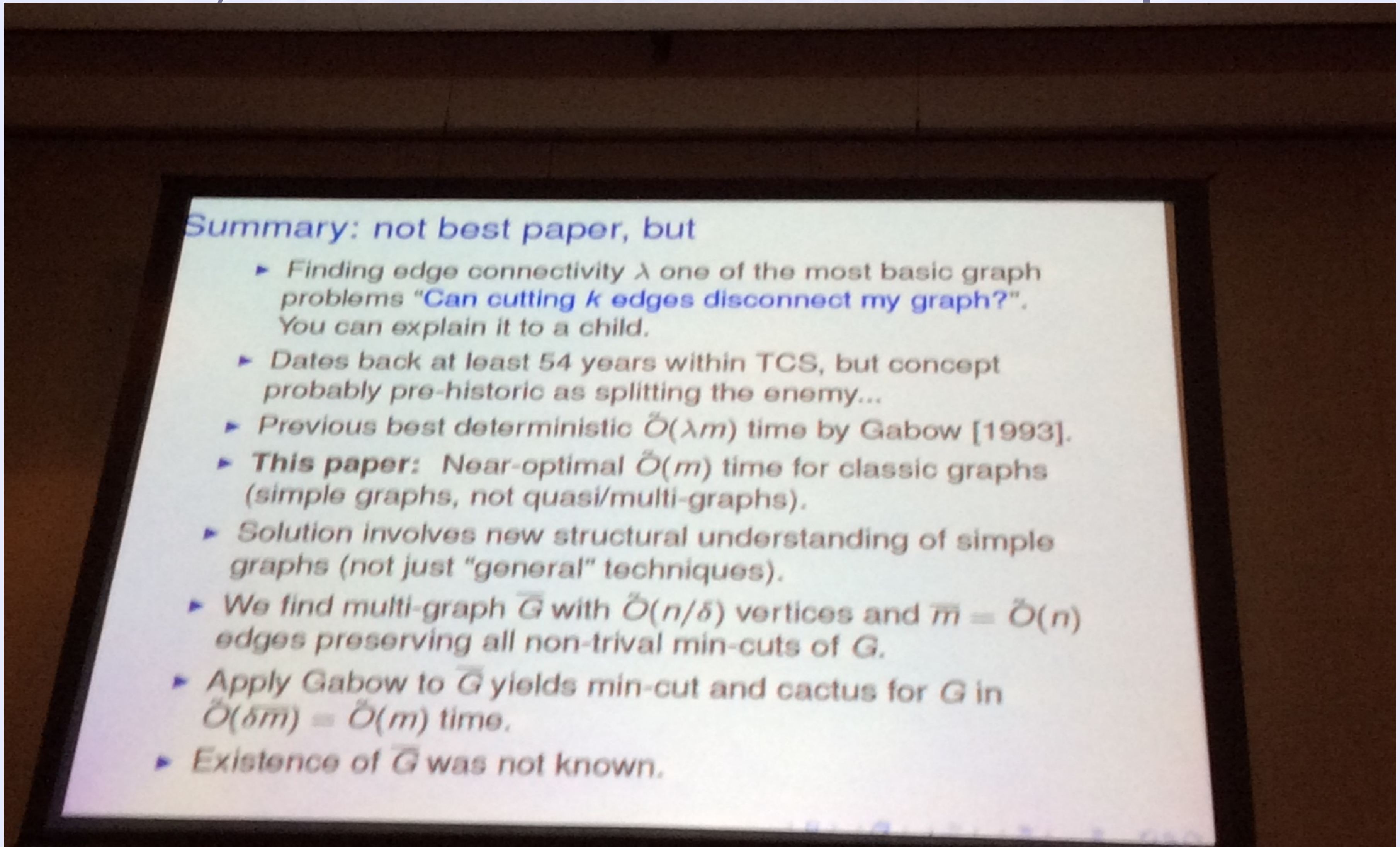
2. Ken-ichi Kawarabayashi and Stephan Kreutzer,
The Directed Grid Theorem

3. Ken-ichi Kawarabayashi and Anastasios(Tasos) Sidiropoulos
Beyond the Euler Characteristic: Approximating the Genus of General Graphs

90/323..

Deterministic Global Minimum Cut of a Simple Graph in Near-linear Time

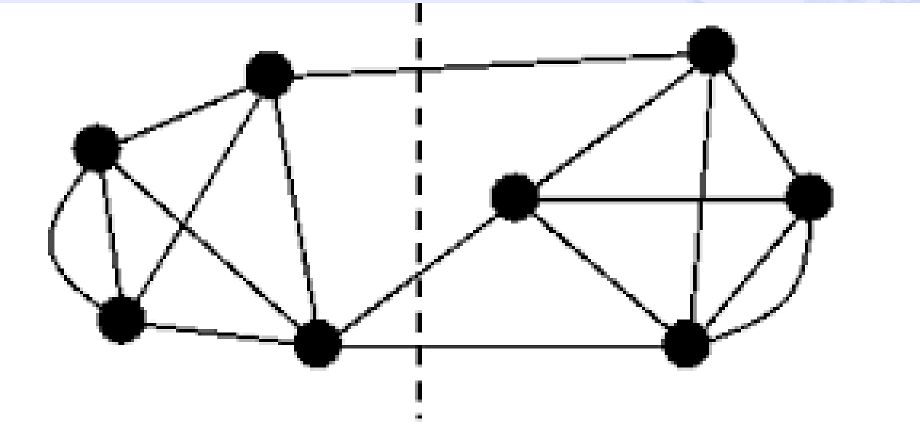
By KK and Mikkel Thorup



STOC'15 Result: Edge Connectivity

Graph Cut: One of the most famous problem

Partition G into (A,B) such that # of edges between A and B is as small as possible.

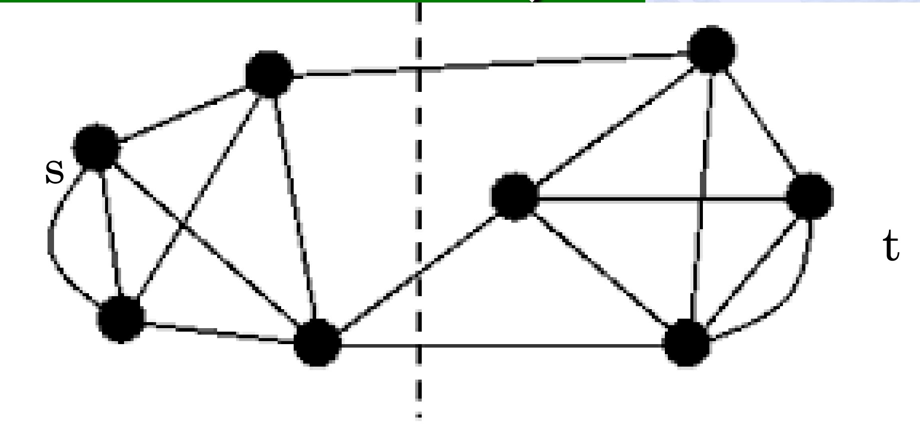


G: n vertices and m edges.
K: cut size

Race by many ``giant'' researchers in theory!

Ford and Fulkerson'56	$O(mn^2)$ ←	Founder of Operation Research !
Even and Tarjan'75	$O(nm^{1.5})$ ←	Turing prize winner
Karzanov and Timofeev'86	$O(n^3)$ ←	Russian researchers
Hao and Orlin'92	$O(nm \log(n^2/m))$	Deterministic
Ibaraki and Nagamochi'92	$O(nm+n^2 \log n)$	Deterministic
Gabow'93	$O(km)$	Deterministic (for simple graphs)
Karger'94	$O(mn^{0.5})$	(Randomize, Monte Carlo, Random Contraction)
Karger and Stein'96	$O(n^2 \log^3 m)$	(Randomize, Monte Carlo)
Karger'99	$O(m \log^3 n)$	(Randomize, Monte Carlo, Tree Packing)
KK and Thorup(STOC'15)	$O(m \log^{10} n)$	Deterministic! (for simple graphs)

Min-Max Theorem(Ford and Fulkerson)



Given s and t,
Max # of edge-disjoint paths (flows)
= Min # of edge cut s and t

Race by many ``giant'' researchers in theory!

Ford and Fulkerson'56	$O(mn^2)$ ←	Founder of Operation Research !
Even and Tarjan'75	$O(nm^{1.5})$ ←	Turing prize winner
Karzanov and Timofeev'86	$O(n^3)$ ←	Russian researchers
Hao and Orlin'92	$O(nm \log(n^2/m))$	Deterministic
Ibaraki and Nagamochi'92	$O(nm+n^2 \log n)$	Deterministic
Gabow'93	$O(km)$	Deterministic (for simple graphs)
Karger'94	$O(mn^{0.5})$	(Randomize, Monte Carlo, Random Contraction)
Karger and Stein'96	$O(n^2 \log^3 m)$	(Randomize, Monte Carlo)
Karger'99	$O(m \log^3 n)$	(Randomize, Monte Carlo, Tree Packing)
KK and Thorup(STOC'15)	$O(m \log^{10} n)$	Deterministic! (for simple graphs)

Random Algorithms: Two kinds

- Monte Carlo Algorithm:

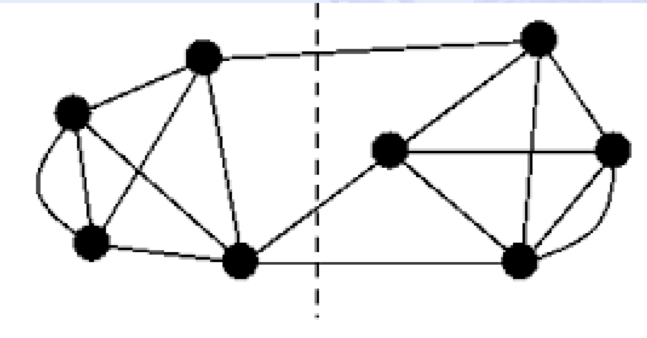
Guarantee the time complexity, and with high probability, the answer is correct.

Kager's mincut: NO WAY to check that the cut is min...

- Las Vegas Algorithm:

Guarantee the correctness, but with small probability, time complexity takes forever..

Why ``simple" graphs?



Key Observation 1:

Let C be a ``minimum" cut (of order at most k). Either

1. One side is trivial (note that min degree is at least k), or
2. Both sides contain at least k-1 vertices..

Our luck:

Can assume that $k > \log^3 m$ (otherwise, we can get a min cut algorithm with running time O(km) by Gabow, and done.)

In 2, we get a ``sparse" cut (i.e., low conductance cut)!

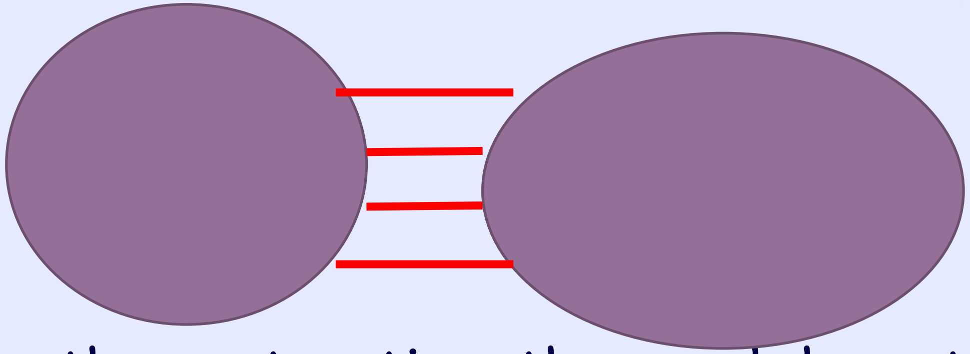
Log n is a ``magic" number… → KEY IDEA! Keep applying sparsest cut!

Contractions!

- Observation 2:

Q: a subgraph s.t. each vertex in Q has degree at least k/2 in Q. If no sparsest cut of conductance k/4 in Q → Q is contractible (preserving all min nontrivial cuts)!

Note: $k > \log^3 n$. So conductance is small..



The idea:

Find contractible subgraphs Q' such that after the contraction, the graph has at most m/k edges (but all nontrivial cuts are there).

→ By Gabow's, we get an O(m) algorithm.

How to find contractible subgraphs? Repeatedly cutting sparsest cuts!

→ When we stuck, we get "contractible" subgraphs!

Some technical components for Sparse cut:

- PageRank! (starting from one vertex) &Sparsest cut! (Andersson, Chung, Lang)

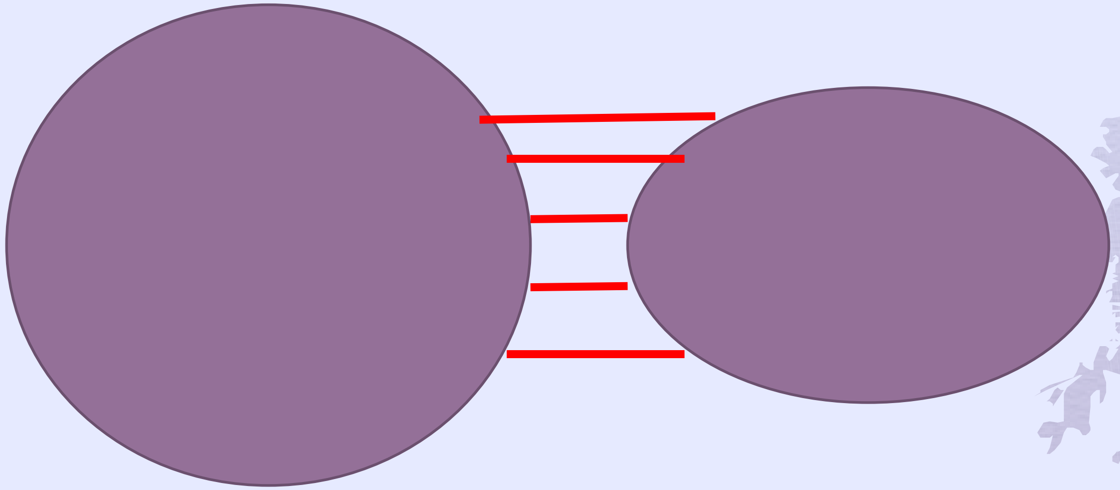
Key Observation:

Let G be a simple graph with min degree k. If min-cut W is not trivial, then # of cut edges of W is at most factor 2/k of # of edges in components.

→ we can use PageRank to find a sparsest cut W' (with error factor log n << k)!

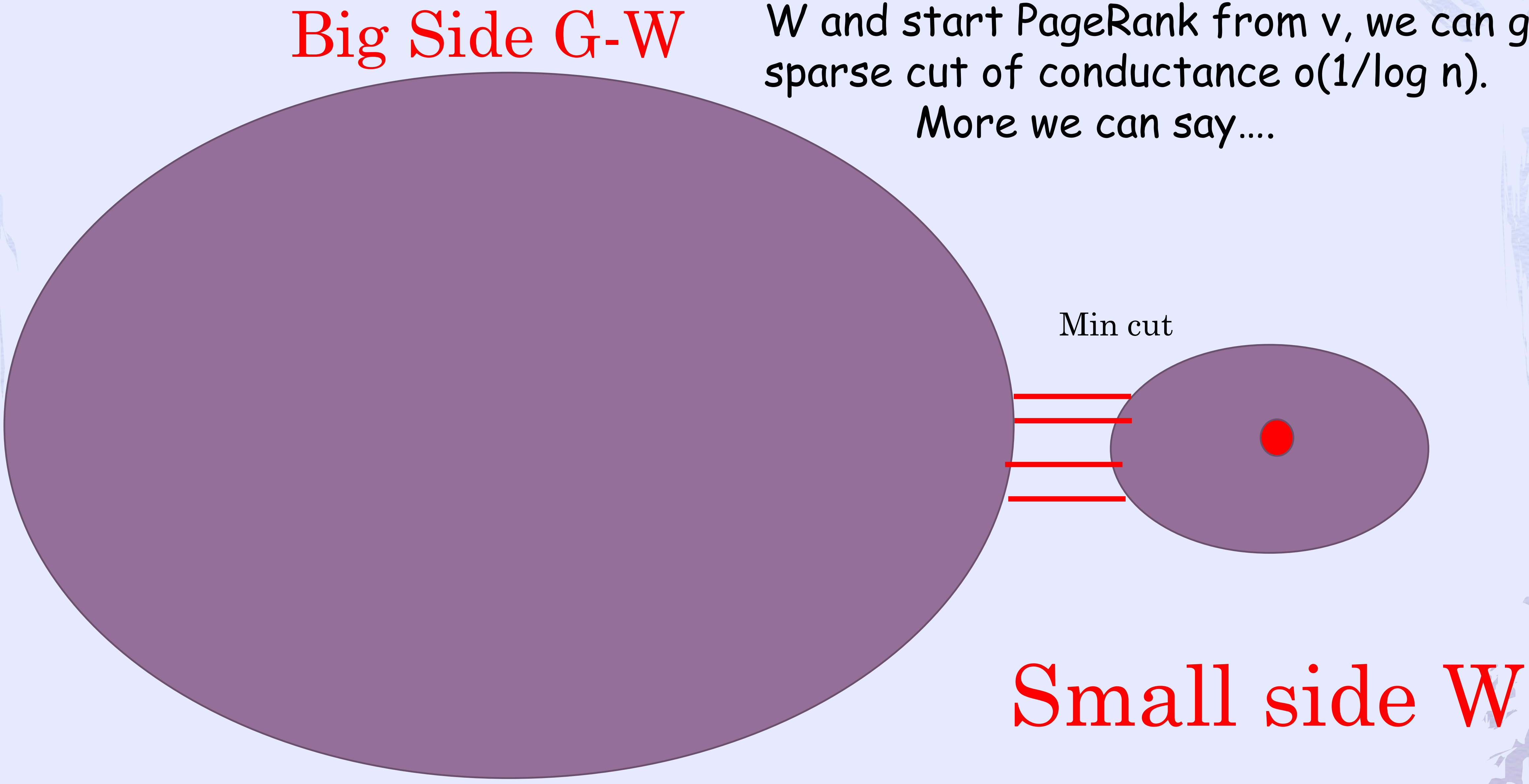
→ # of cut edges for W' is at most factor (2 log n/k) of # of edges in W' in O(m)!

k > $\log^5 m$

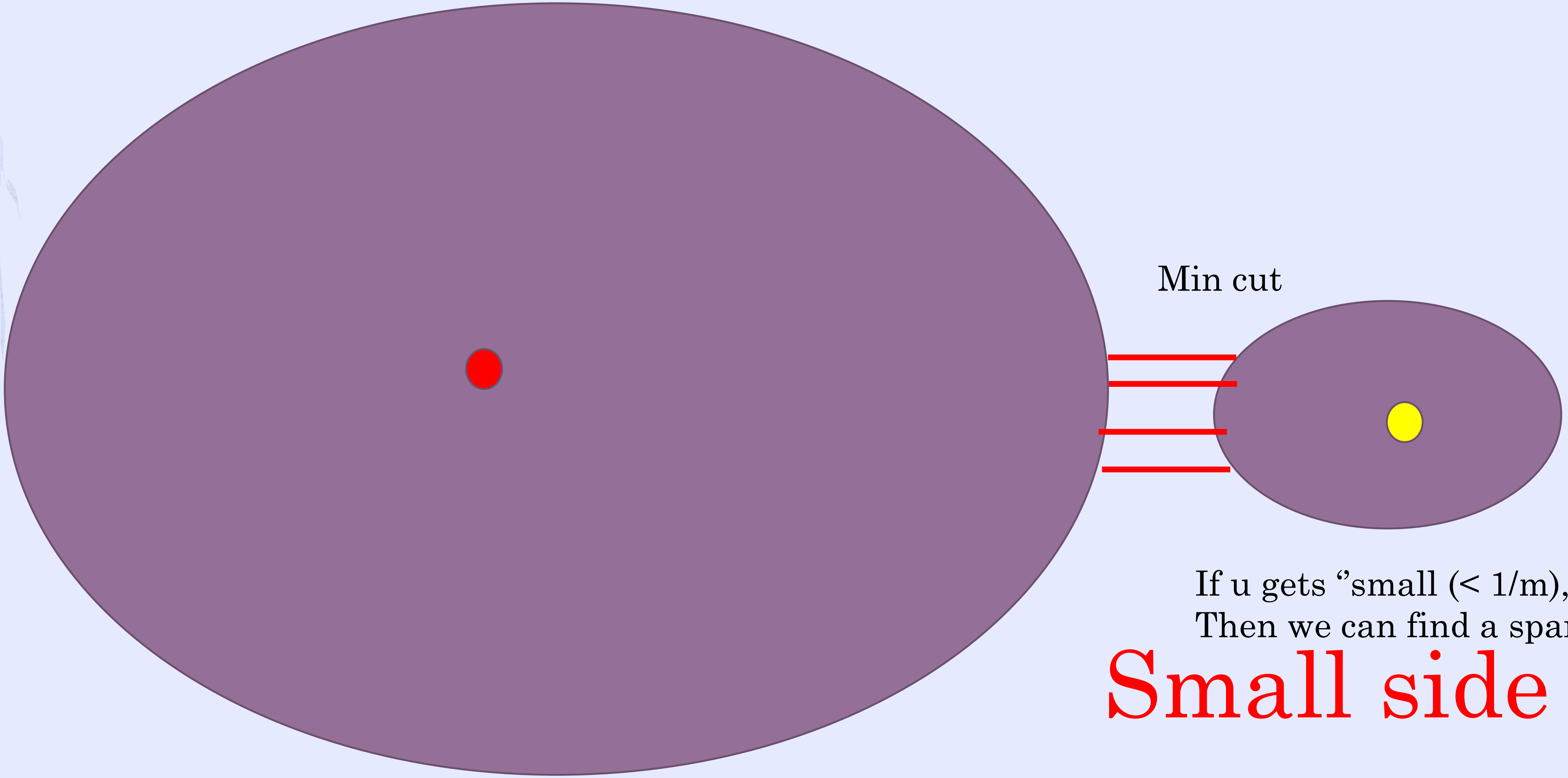


If we can ``correctly" guess a vertex v in W and start PageRank from v, we can get a sparse cut of conductance o(1/log n).

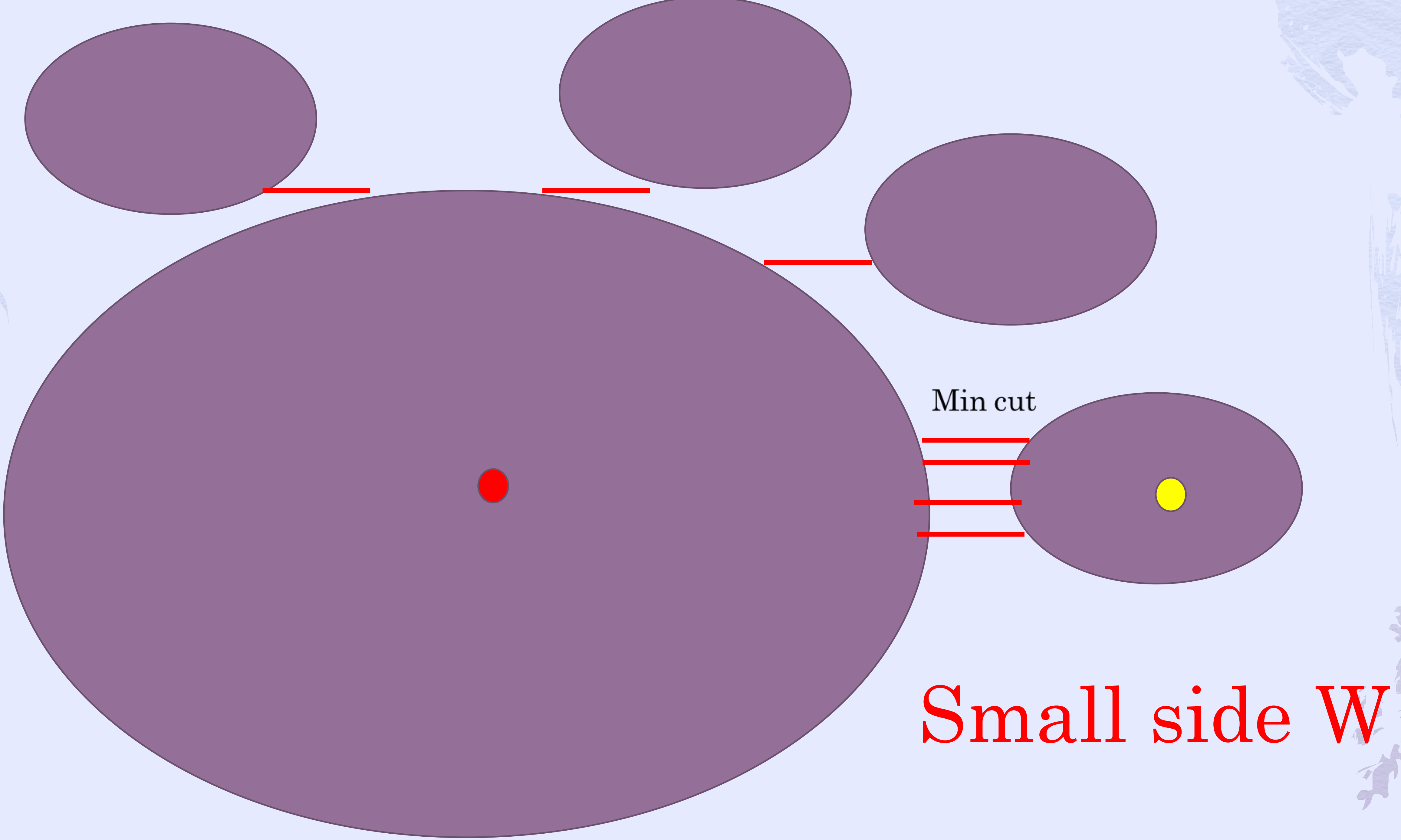
More we can say….

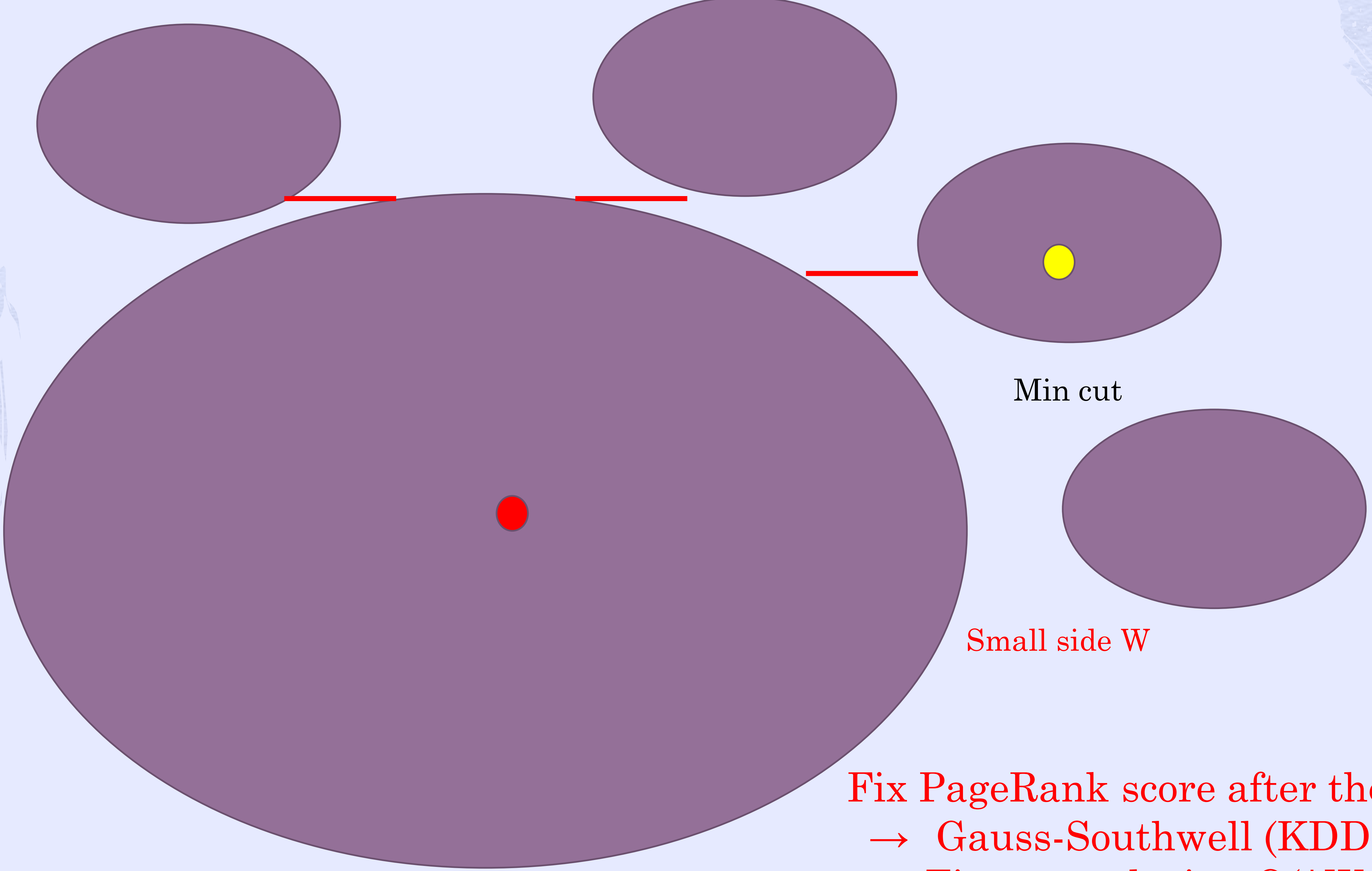


End Game!



If u gets ”small (< 1/m),
Then we can find a sparse cut!


Min cut
Small side W



Fix PageRank score after the cut of W

→ Gauss-Southwell (KDD'15)!

→ Time complexity: O(|W|)

Finally

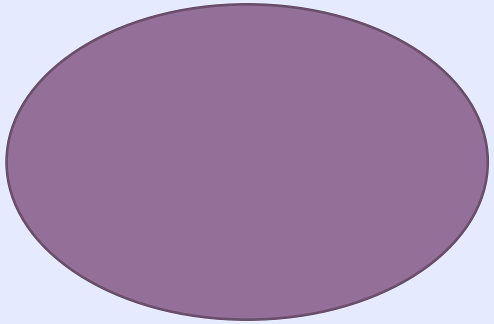
- If we cannot find low-conductance (sparse) cut in W, then W is contractible.
- The point:

Only apply O(log n) iterations to the small side W → average degree is k – $O(\log^2 n) \gg k/2$...

- Can do each ``small'' component separately..

→ spend only O(m) in total. Then we can find contractible subgraphs!

In the end, we have a graph with O(m/k) edges.

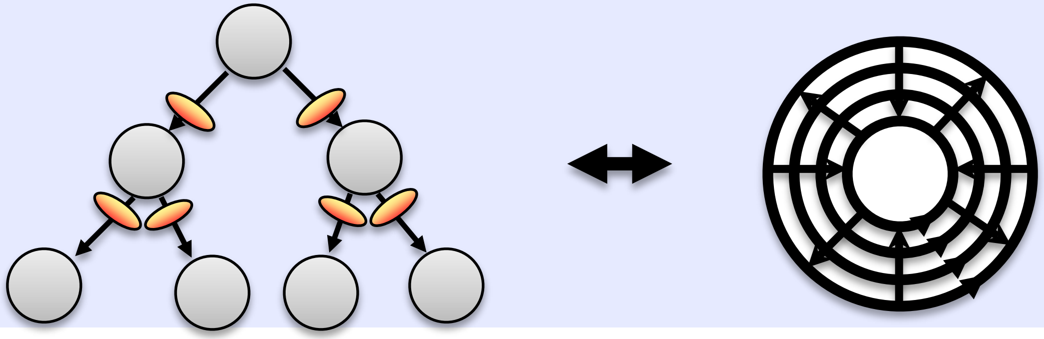


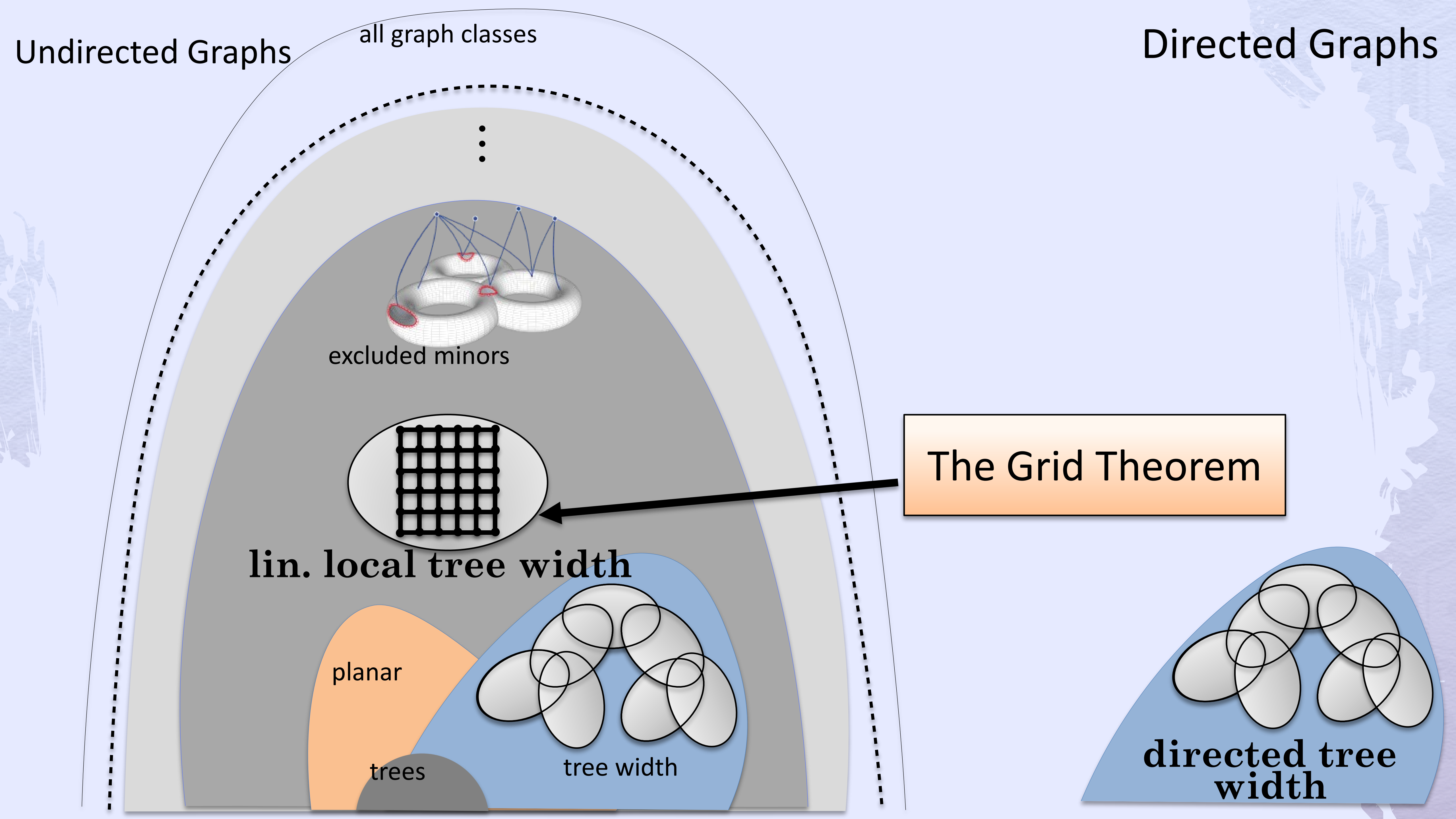
Well, cheating.....

The Directed Grid Theorem

Ken-ichi Kawarabayashi, NII, Tokyo
Stephan Kreutzer, TU Berlin

（ICALPのほうが詳しい）




Undirected Graphs
all graph classes
Directed Graphs
excluded minors
The Grid Theorem
lin. local tree width
planar
trees
tree width
directed tree width

The main motivation of this talk

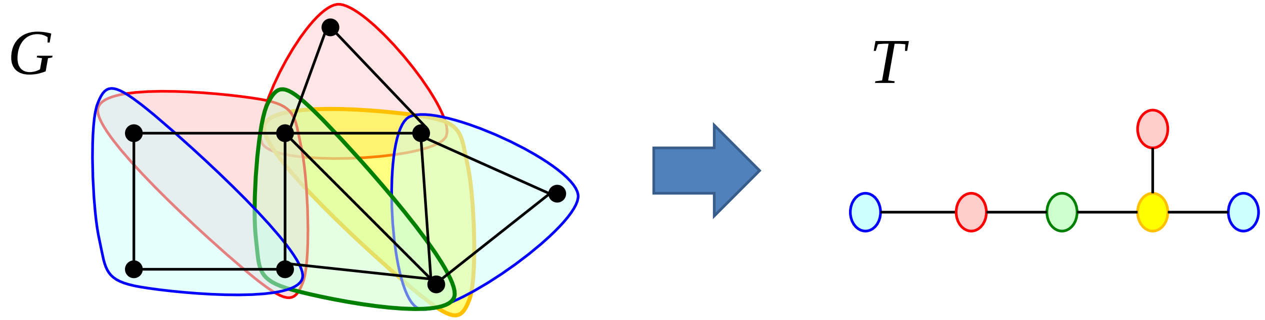
WHAT ABOUT DIGRAPHS?

Can we do the same thing?

Warning: Not really known much.
Purposes of this talk: report some progress
future direction
and many open questions

Treewidth

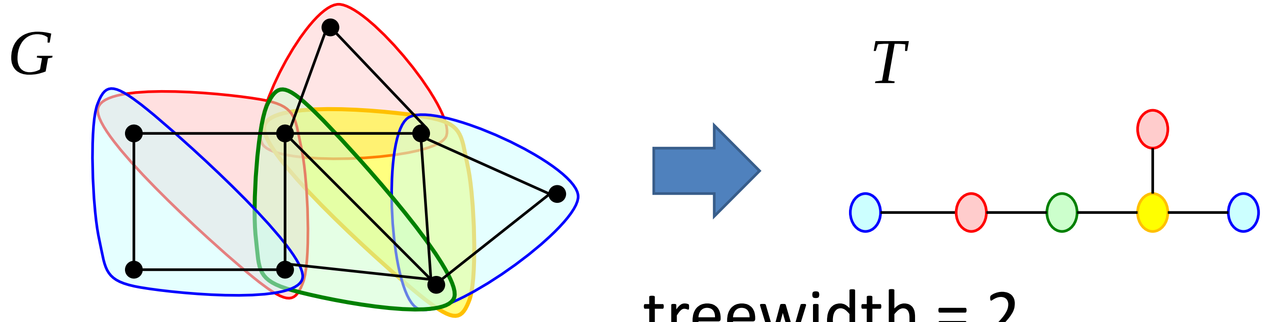
- $(T, \boldsymbol{W})$ is a tree decomposition of $G = (V, E)$
  - T is a tree, $\boldsymbol{W} = \{W_t \subseteq V \mid t \in V(T)\}$
  - ⇔ $\bigcup_{t \in V(T)} W_t = V$, and every edge has both ends in some W_t
  - If t lies one the path in T between t' and t'', then $W_t \subseteq W_{t'} \cap W_{t''}$



Tree-width:
How close to a Tree
Width=1 ⇔ Tree

Treewidth

- $(T, \boldsymbol{W})$ is a tree decomposition of $G = (V, E)$
  - T is a tree, $\boldsymbol{W} = \{W_t \subseteq V \mid t \in V(T)\}$
  - ⇔ $\bigcup_{t \in V(T)} W_t = V$, and every edge has both ends in some W_t
  - If t lies one the path in T between t' and t'', then $W_t \subseteq W_{t'} \cap W_{t''}$
- width of $(T, \boldsymbol{W})$:= $\max_t |W_t| - 1$
- treewidth of G := min. width over all tree decompositions



treewidth = 2

Tree-width:
How close to a Tree
Width=1 ⇔ Tree

Importance of Tree-width

- (Algorithm) Many hard NP-hard problems can be solved in linear time.
- (Algorithm) Fixed parameter-tractability
- (Graph Theory) Great tools in Structure Graph Theory
- (Logic) Courcelle's theorem: every graph property that is definable in MSO_2 can be decided in linear time for graphs of bounded tree-width!
- (General) AI, Database, Data mining, Social Network, Programming Language etc.

Treewidth and Grid minor (most important result in treewidth..)

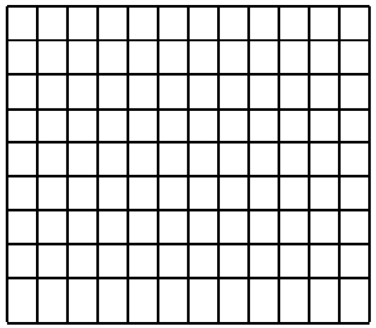
Thm (Robertson-Seymour, 1986) The grid minor theorem

For any r, there exists an integer $f(r)$ s.t. for any graph G, either

- treewidth of G is $\leq f(r)$
- G has an $r \times r$ -grid-minor

Known results

- $f(r) = 2^{O(r^5)}$, $f(r) = \Omega(r^2 \log r)$ (Robertson-Seymour-Thomas [1994], Diestel et al. [1999])



Tree-width r

G contains an H-minor -> H can be obtained from G by deleting edges and contracting edges

Treewidth and Grid minor(most important result in treewidth..)

Thm (Robertson-Seymour, 1986) The grid minor theorem

For any r, there exists an integer $f(r)$ s.t. for any graph G, either

- treewidth of G is $\leq f(r)$
- G has an $r \times r$ -grid-minor

Known results

- $f(r) = 2^{O(r^5)}$, $f(r) = \Omega(r^2 \log r)$ (Robertson-Seymour-Thomas [1994], Diestel et al. [1999])
- G : planar $f(r) = O(r)$ (Robertson-Seymour-Thomas [1994])
- G : bounded genus $f(r) = O(r)$ (Demaine, Fomin, Hajiaghayi, Thilikos, [2005])
- G : H-minor-free $f(r) = c_H \cdot r$ (Demaine-Hajiaghayi [2008])
- G : $K_{3,k}$-minor-free $f(r) = 20^{4k} \cdot r$ (Demaine-Hajiaghayi –KK [2009])

Treewidth and Grid minor(most important result in treewidth..)

Thm (Robertson-Seymour, 1986) The grid minor theorem

For any r, there exists an integer $f(r)$ s.t. for any graph G, either

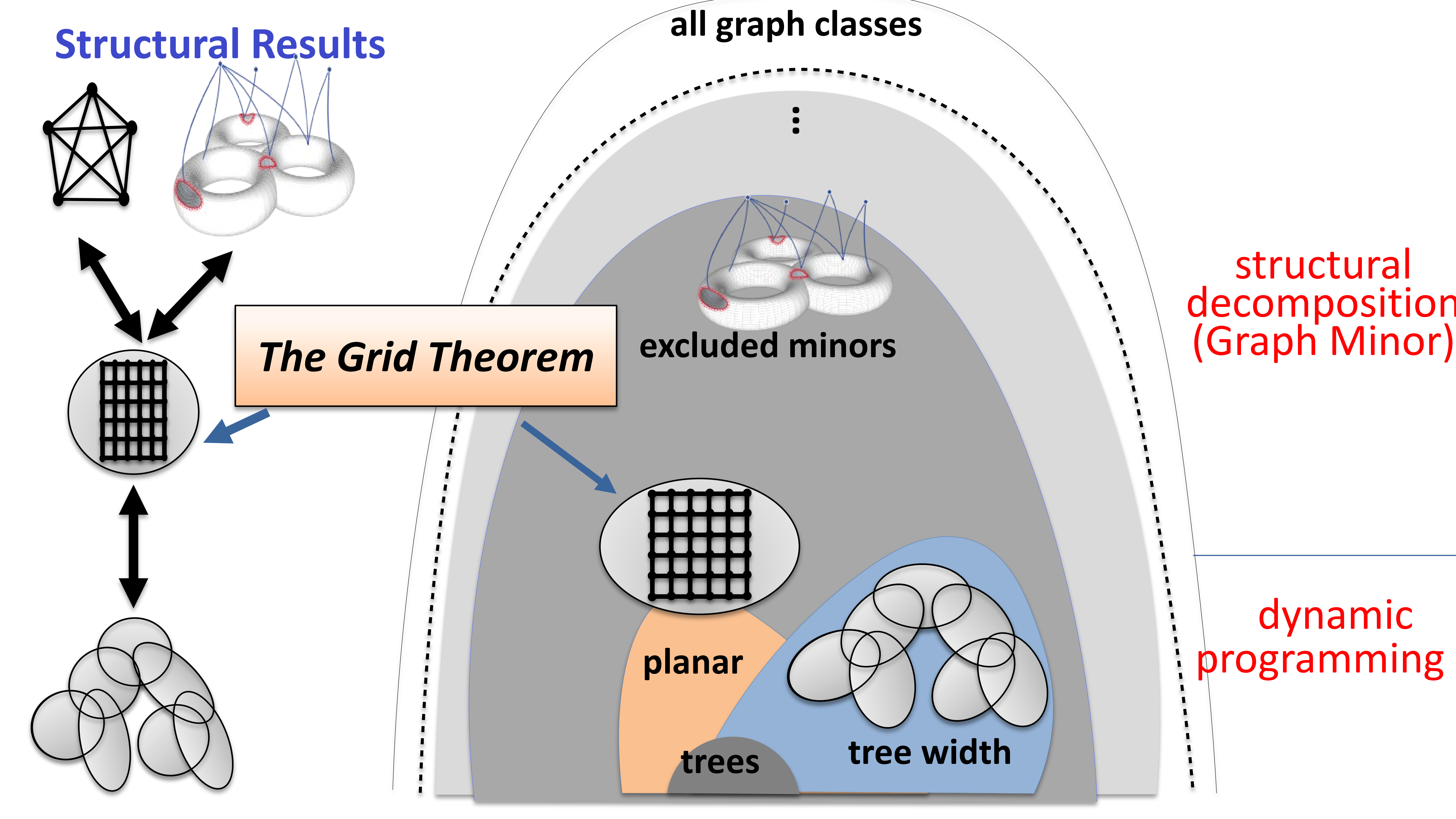
- treewidth of G is $\leq f(r)$
- G has an $r \times r$ -grid-minor

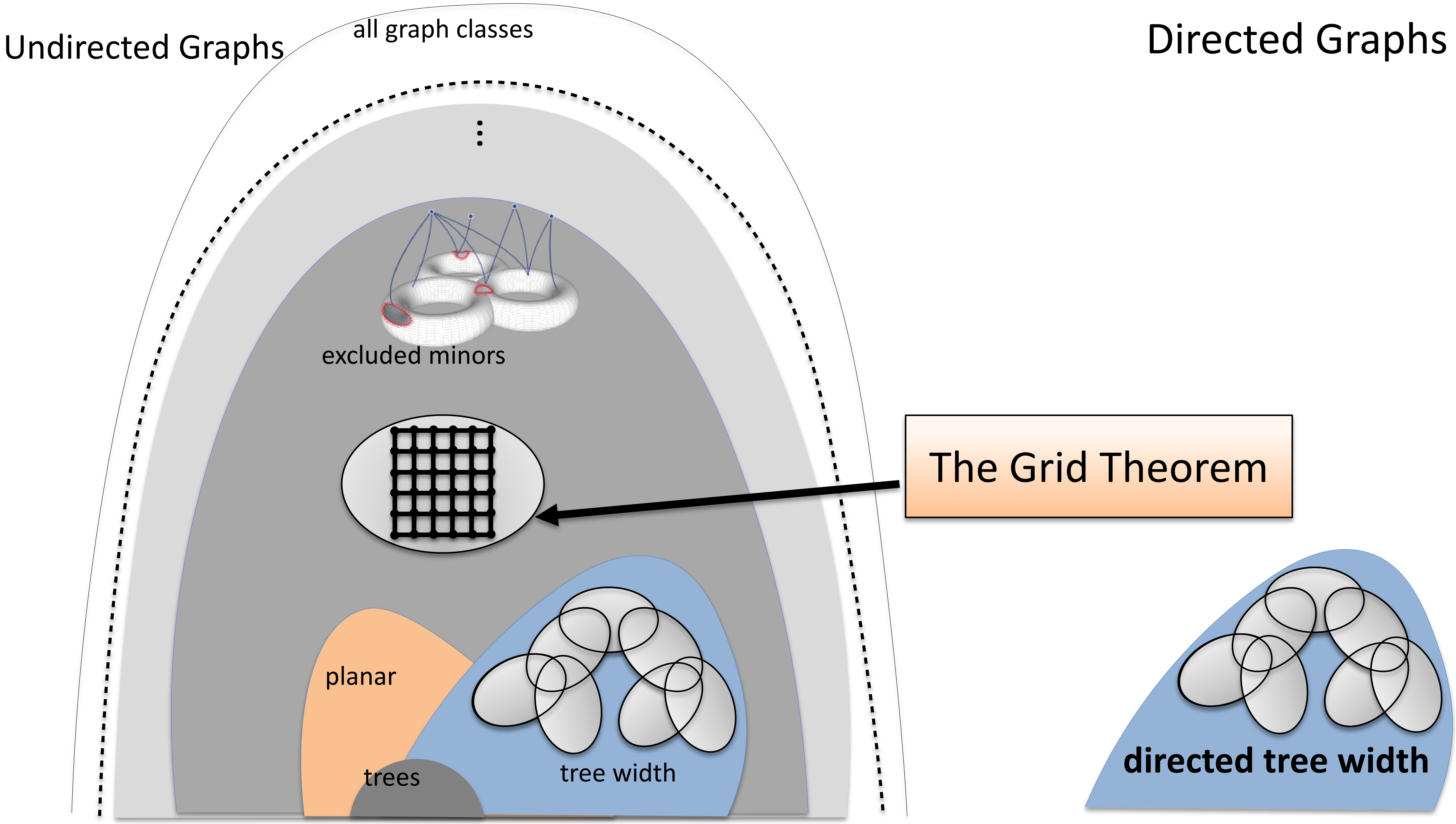
Known results

- $f(r) = 2^{O(r^5)}$, $f(r) = \Omega(r^2 \log r)$ (Robertson-Seymour-Thomas [1994], Diestel et al. [1999])
- G : H-minor-free $f(r) = |V(H)|^{O(|E(H)|)} \cdot r$ (Kawarabayashi-Kobayashi [2012])
- G : general $f(r) = 2^{O(r^2 \log r)}$ (Kawarabayashi-Kobayashi, Leaf-Seymour[2012])
- G: general $f(r) = r^{O(1)}$ (Chekuri-Chuzoy[2013])

Importance of the grid minor theorem:

1. Fixed Parameter Tractability(FPT) , bidimetionality(Large vertex cover..)
2. Logic (FOL etc..)
3. Combinatorial Optimization(Routing..)


Structural Results
all graph classes
The Grid Theorem
excluded minors
structural
decomposition
(Graph Minor)
planar
trees
tree width
dynamic
programming


Undirected Graphs
all graph classes
Directed Graphs
excluded minors
The Grid Theorem
planar
trees
tree width
directed tree width

What about digraphs?

Seems much harder!

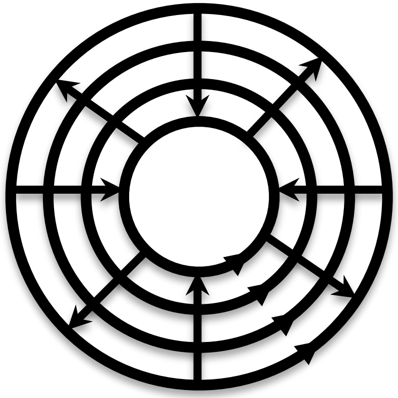
Q.1 What is ``tree-width" for digraphs?

Q.2 What is ``minor" for digraphs?

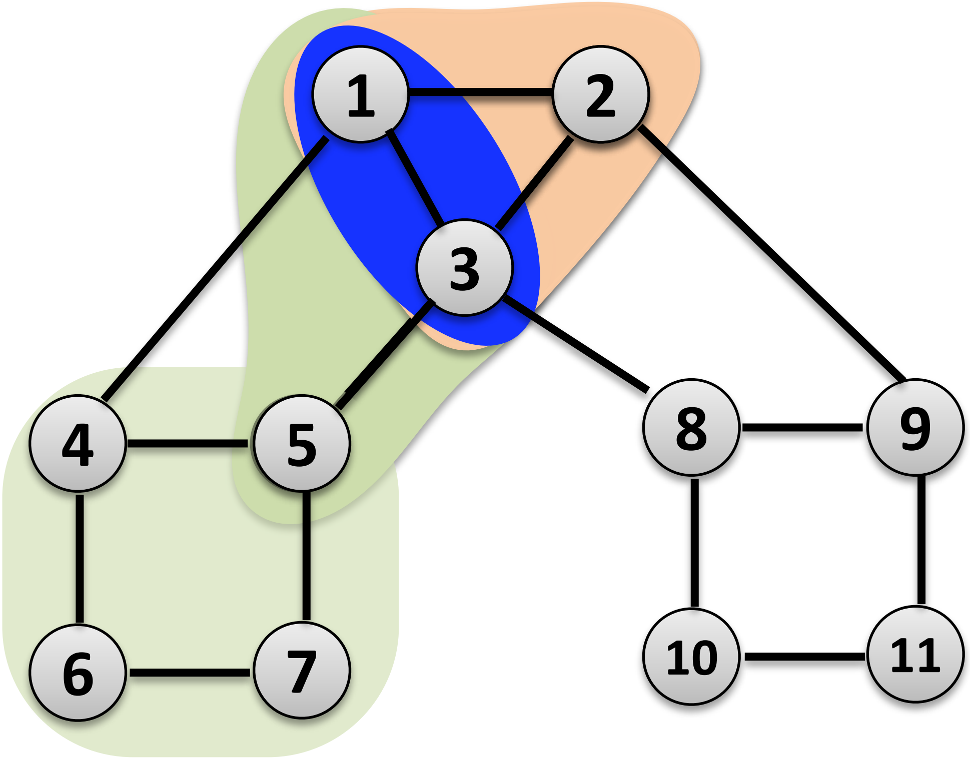
What is grid minor for digraphs?

What should be ``grid?

1. Many cycles!
2. Globally connected

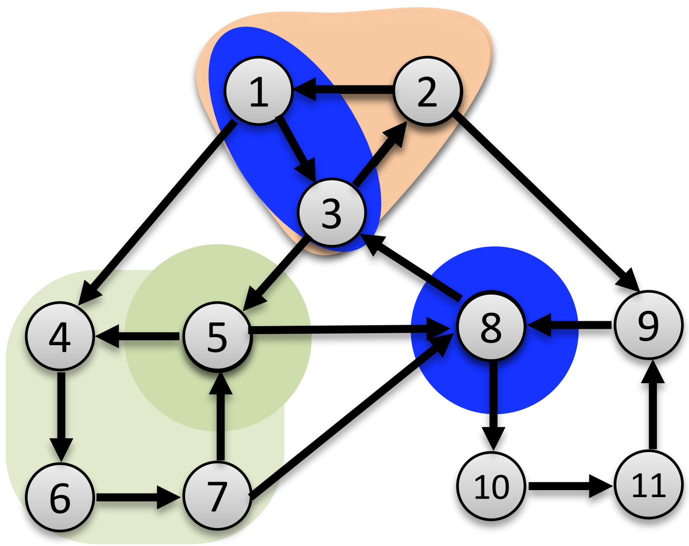


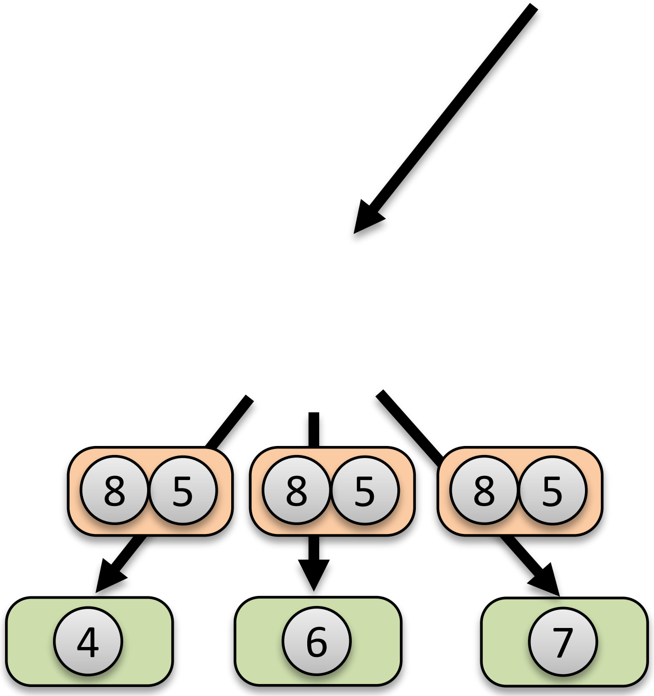
Tree-width for undirected graphs



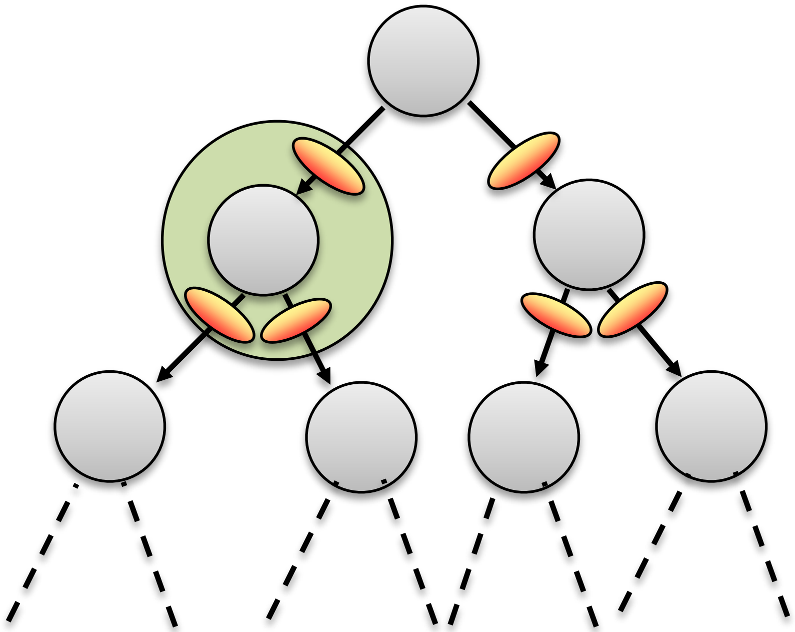
Q1. What is Directed Tree-Width?

- **Defined analogous to undirected tree width but based on strong separators**





Directed Tree Width



Directed tree-width:
How close to a DAG
(directed acyclic graph)
Width=1 ⇔ DAG

Definition.

(Reed'97) (Johnson, Robertson, Seymour, Thomas 01)

Directed tree decomposition of G: triple (T, β, γ)

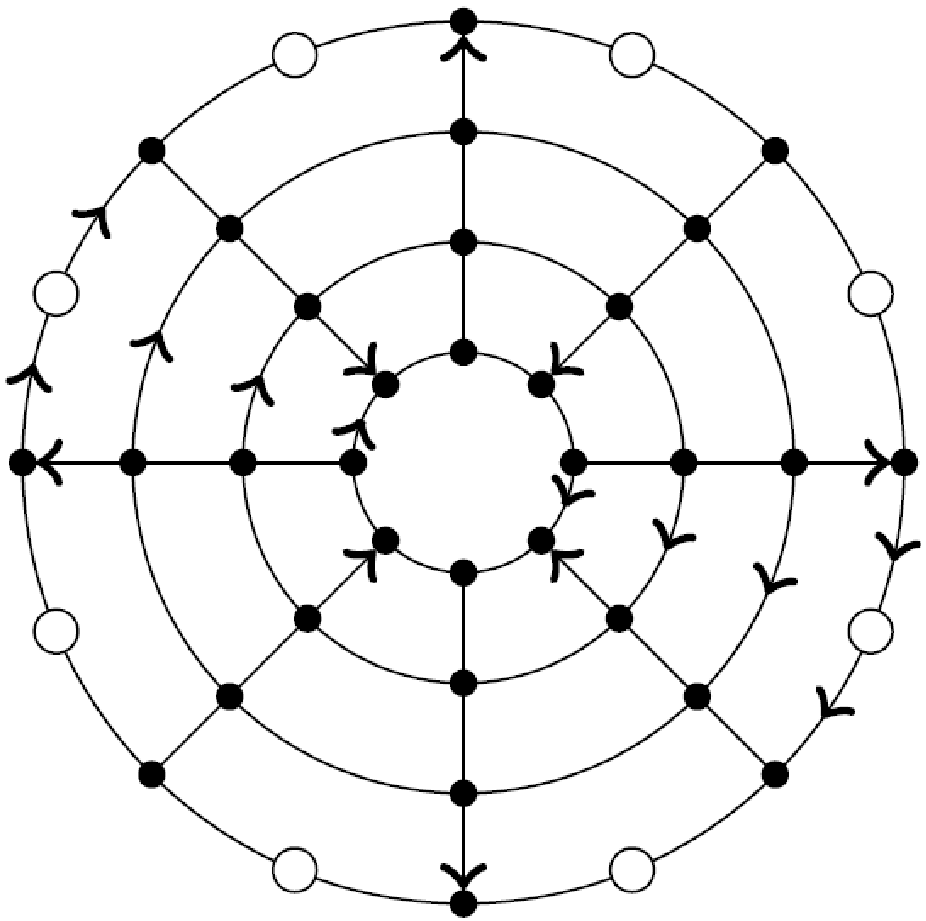
- bags $\beta(t) \subseteq V(G)$ form a partition of the vertex set of G
- for all $e=(s,t) \in E(T)$: $\gamma(e) \subseteq V(G)$

$$\beta(T_t) := \cup\{\beta(t') : t \leq_T t'\} \text{ strong component of } G - \gamma(e)$$

The **width** is the minimum of $|\beta(t) \cup \bigcup_{e \sim t} \gamma(e)|$ over all $t \in V(T)$.

CONJECTURE (Alon, Reed, Robertson, Seymour, Thomas, 1995)

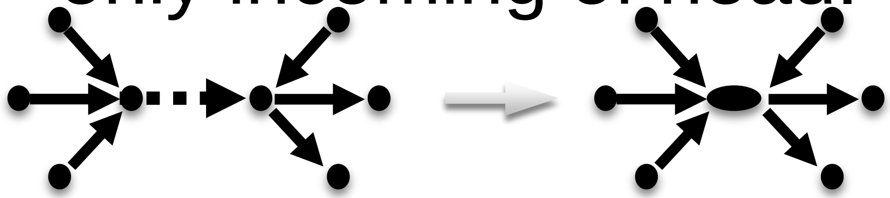
There is a function f such that every digraph of tree-width at least $f(k)$ has a cylindrical $k \times k$ grid minor.



Directed Grid should be

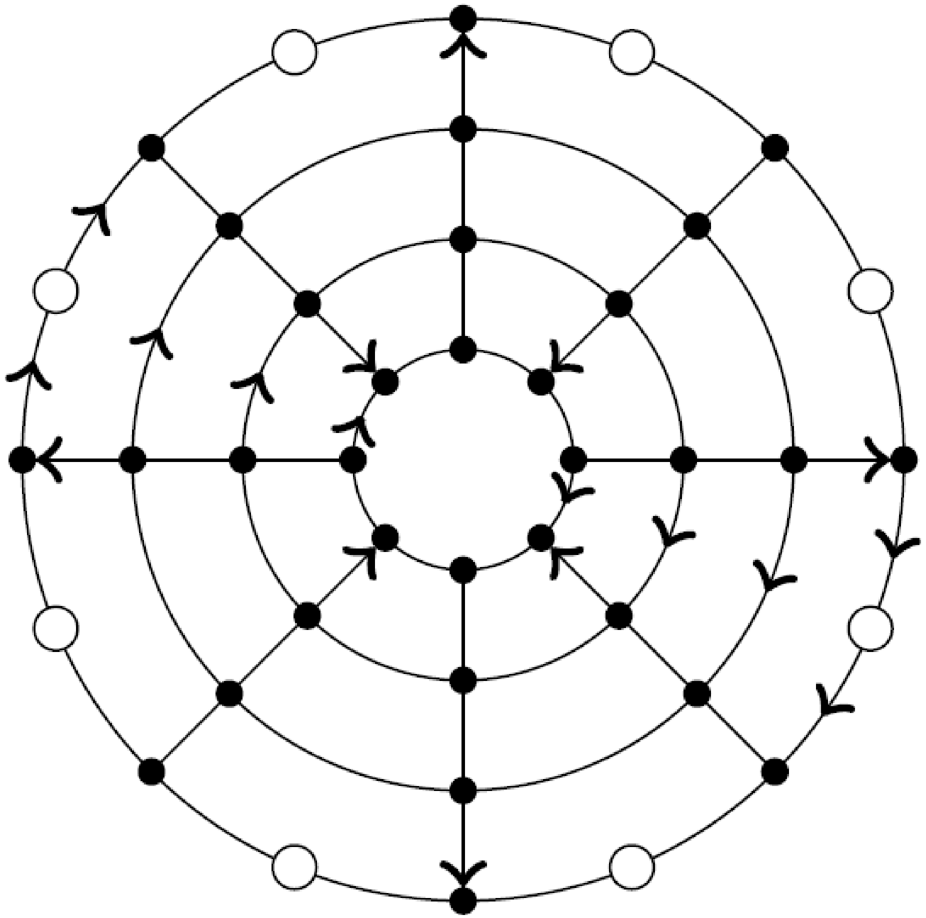
1. Many cycles
2. Globally connected
3. Directed tree-width at least k

Minor: contract an edge if only outgoing of tail or only incoming of head.



CONJECTURE (Alon, Reed, Robertson, Seymour, Thomas, 1995)

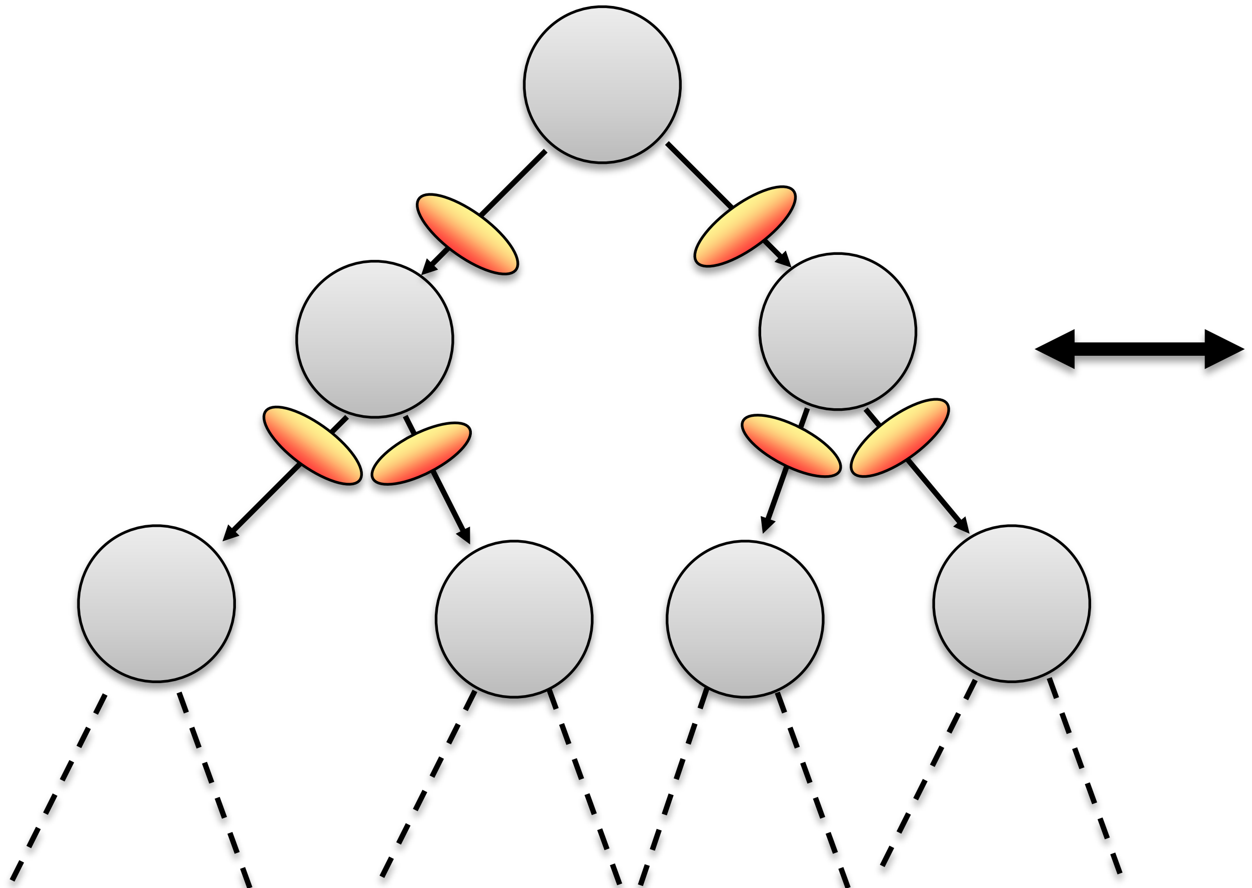
There is a function f such that every digraph of tree-width at least f(k) has a cylindrical k × k grid minor.

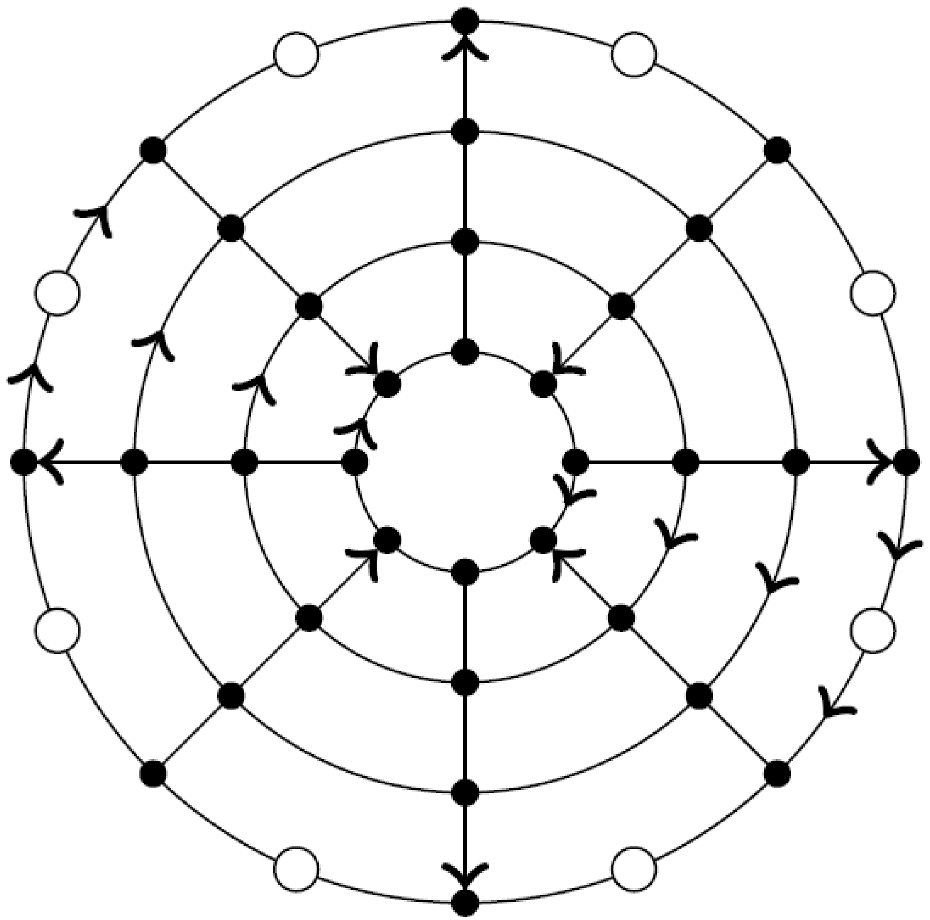


History:
True for planar graphs
(Johnson, Robertson, Seymour, Thomas, 99)
True for minor-closed
(KK& Kreutzer, SODA'14)
True if ``half-integral''
(KK&Kreuzer'STOC'14)
General case?? -> This is our main result!

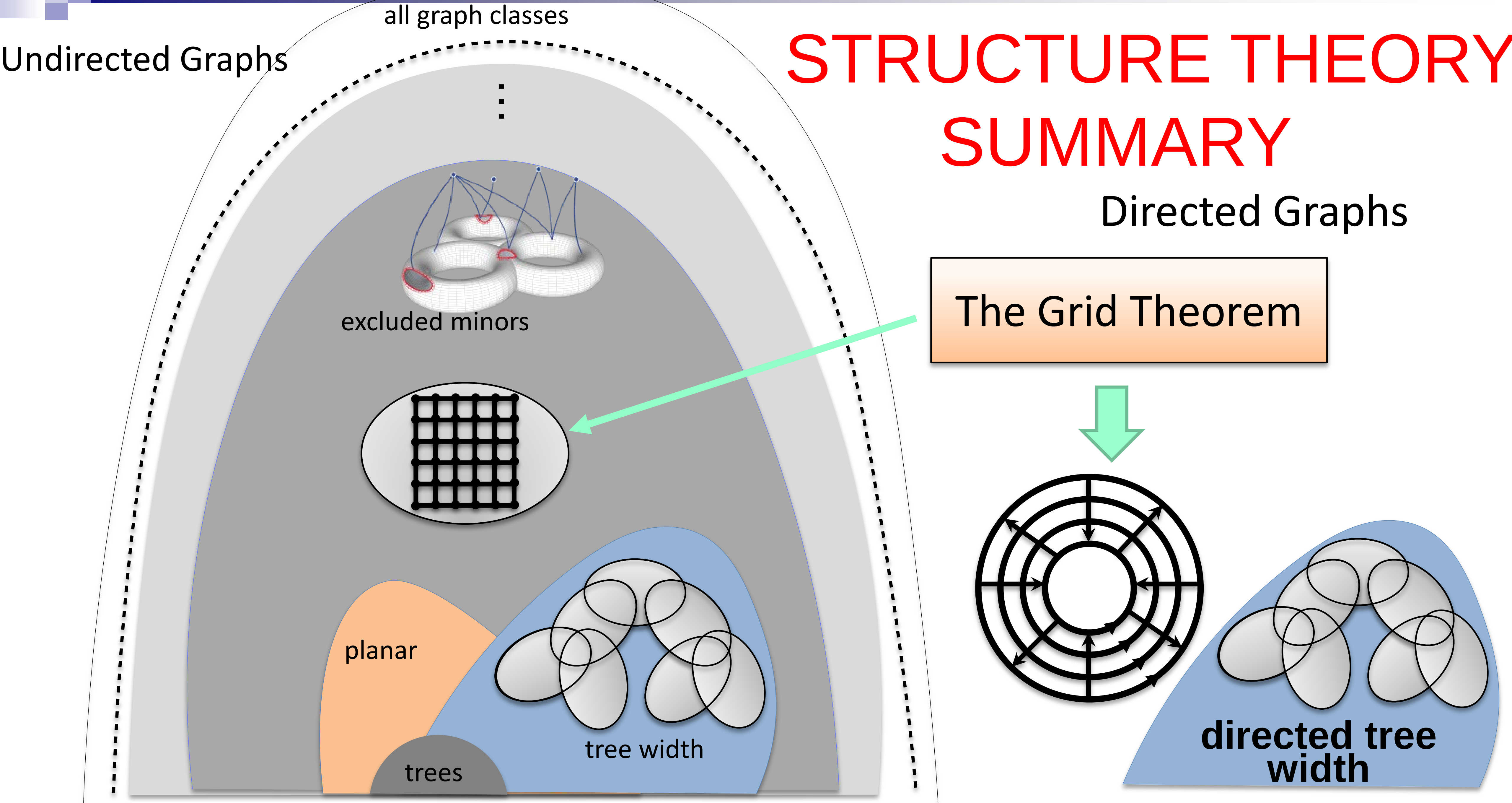
Main Theorem (KK and Kreutzer, STOC 2015)

There is a function f such that every digraph of tree-width at least $f(k)$ has a cylindrical $k \times k$ grid minor. Proof > 50 pages….





STRUCTURE THEORY SUMMARY



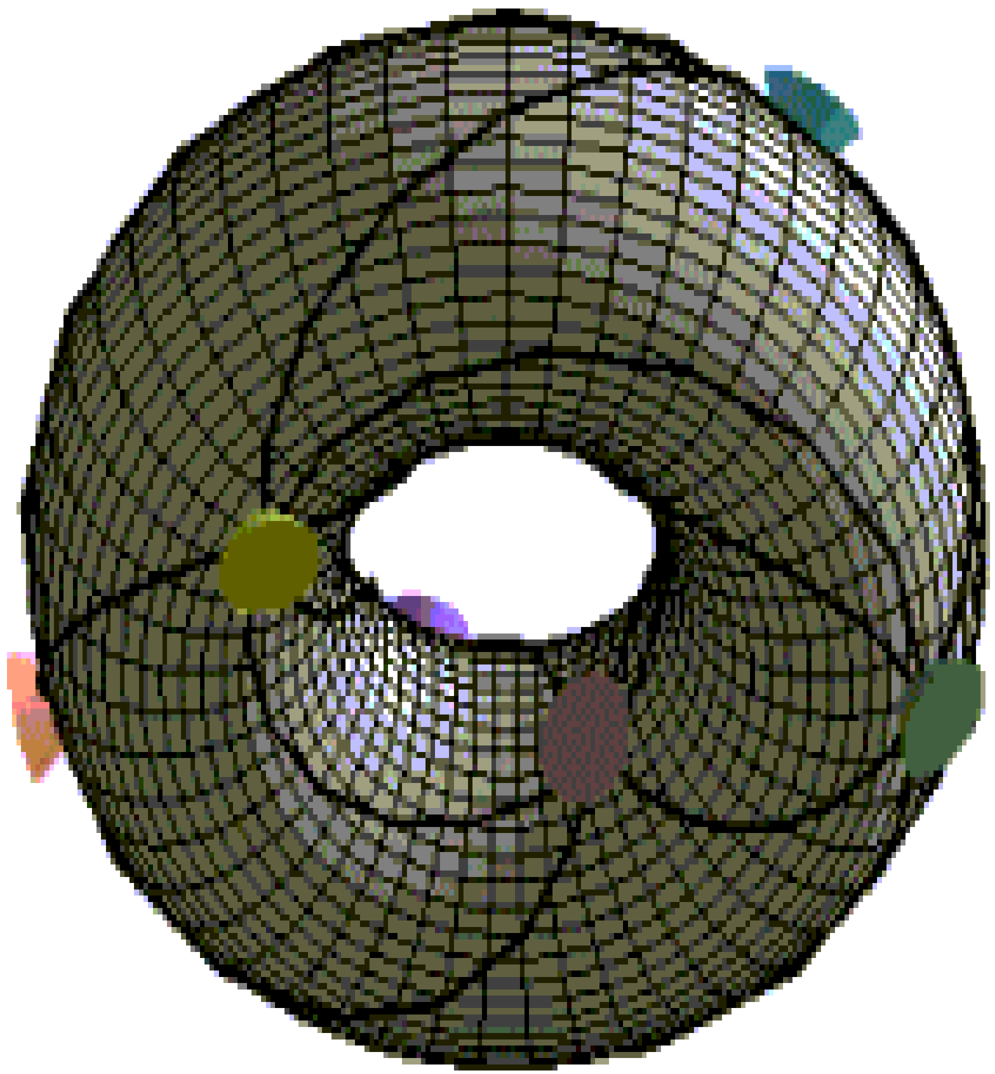
Beyond the Euler genus: Approximating the genus of general graphs

Ken-ichi Kawarabayashi
NII, Tokyo
Joint work with Anastasios(Tasos) Sidiropoulos

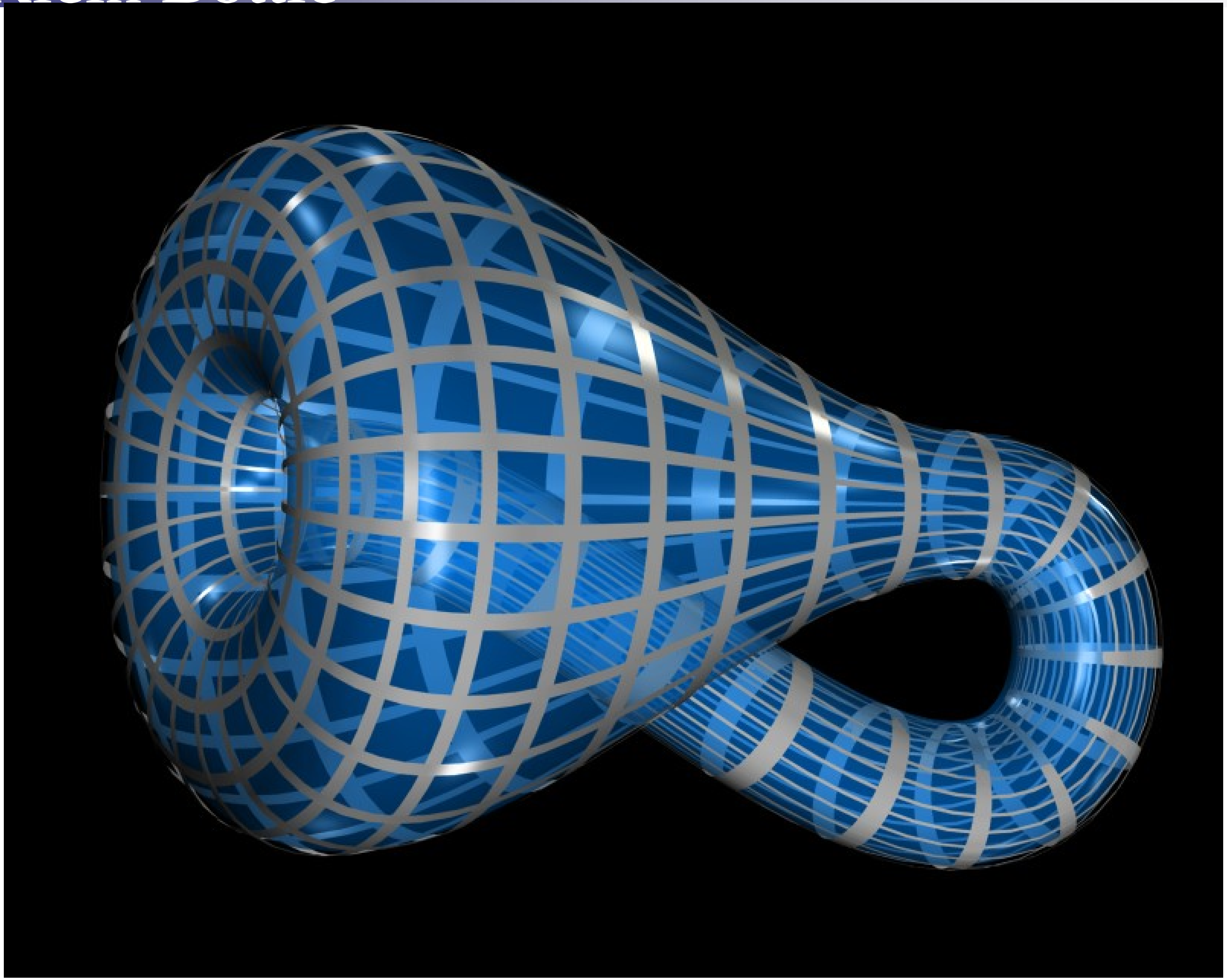
To appear in STOC’15

Surface

- By a surface, we mean a compact 2-dimensional manifold.
- We consider plane with crosscaps or handles.
- Plane + crosscap: Projective planar.
- Plane + handle : Torus
- Plane + two crosscaps : Klein bottle



Klein Bottle



Embedding into a surface

- Embed graph in a surface with no edge crossings.
- Minor-closed.
- Euler genus of complete graphs and complete bipartite graphs are known (Heawood 1890!)
- But very little about other graphs....

- Problem(One of original Garey-Johnson)

What is the genus of a given graph? Can you compute?

- NP-complete to determine Euler genus of a given graph. (Thomassen, 1988)

Embedding into a surface

- For fixed Euler genus g, $O(n^g)$ algorithm. (Filotti, Miller and Reif, 1990)
- $O(n^3)$ algorithm. (Robertson and Seymour, 1995)
- Linear time algorithm. (Mohar, 1997)
- Mohar's algorithm gives either an embedding in the surface of Euler genus k or an obstruction (One of minimal forbidden minors.)

New Algorithm(FOCS'08)

- With B. Reed and B. Mohar
- We get another linear time algorithm.
- Better in the following sense:

1. Proof < 25 pages (Mohar's proof > 100 pages)
2. Hidden constant is better. But 2^g

Approximation Algorithm

- No way to compute if g is bigger than log n.

- NP-hard to decide g (Thomassen).

- Trivial approximation: O(n/g).

Euler Formula: |V|-|E|+|F|=2-g → O(n/g)-approximation.

- Essentially nothing is known between NP-hardness and Trivial bound!
- No hardness result is known! (O(1) is NOT ruled out)

Our main result: First ``non-trivial'' approximation

Theorem: Given a graph G and an integer g, in P, we can either

1. Correctly determine that G cannot be embedded in a surface of Euler genus g, or
2. Output an embedding of G in a surface of Euler genus $g^{200} \log^{150} n$.

Corollary. $O(n^{1-c})$-approximation algorithm to compute Euler genus

For some small (but absolute constant) c.