

Audition CPJ 122

Alexandre Vigny

<https://alexandre-vigny.github.io/cpj122.pdf>

June 13, 2023

Alexandre Vigny



- 31 years old, born in 1992.
- PhD defense September 2018 (*5 years ago*).
- Living in Bremen, Germany.

- Master in University Paris Diderot, 2015.
Logique Mathématique et Fondement de l'Informatique (LMFI).
- PhD in University Paris Diderot. (3 years)
With Arnaud Durand & Luc Segoufin
- Post-doc in Warsaw. (1 year)
With Szymon Toruńczyk & Mikołaj Bojańczyk
- Post-doc in Bremen. (3 years)
With Sebastian Siebertz

Summary

Area of Research

- Graph theory
- Logic
- Distributed computing

Highlights

- Publication in J.ACM
- 2 Upcoming journal papers
- 9 Conference papers
- Co-organizer of a workshop
 - PODC-DARe: Distributed Algorithms on
 - REalistic network models

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PODC-DARe: Distributed Algorithms on
REalistic network models

Teaching

- In Paris (3 years)
~ 180h
- In Bremen (3 years)
~ 270h

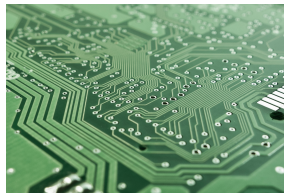
Highlights

- Creation of syllabuses
- Responsible for two courses
- All level bachelor to master
- Both in French and English

Algorithmic graph theory

Given a graph G and a property P : “Does G satisfy P ?”

→ Is G planar?

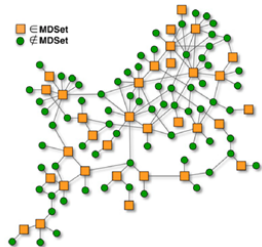


Algorithmic graph theory

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→ Does G have a k -dominating set?



Algorithmic graph theory

Given a graph G and a property P : “Does G satisfy P ?”

→ Is G planar?

→ Does G have a k -dominating set?

→ Is G connected?



Goal: Efficient algorithms ...

... at least for restricted graph classes and/or simple properties.

Logic

First-order (FO) logic

- Can express k -independent set: *There are k vertices, that are not adjacent*
$$\exists x_1 \dots \exists x_k \bigwedge_{i < j} (\neg E(x_i, x_j) \wedge x_i \neq x_j)$$
- Cannot express : connectivity, planarity, 2-colorability, ...

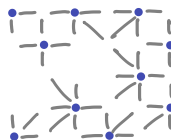
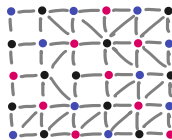
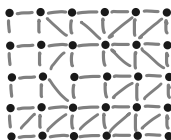
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Monadic second-order (MSO) logic

- More general than FO
- Can express : 3-colorability:
$$\exists X_1 \exists X_2 \exists X_3 (\forall x \bigvee_{i < 3} x \in X_i) \wedge (\forall x \forall y E(x, y) \rightarrow \bigwedge_{i < 3} (x \notin X_i \vee y \notin X_i))$$



Distributed computing

Distributed Computing : Local model

- Different notion of **efficient**
- Time needed VS Information needed

Distributed computing

Distributed Computing : Local model

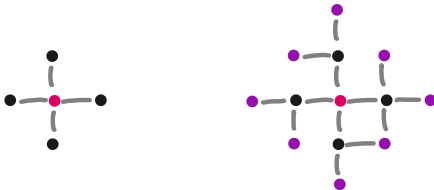
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Distributed computing

Distributed Computing : Local model

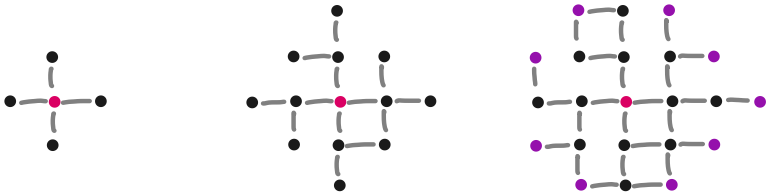
- Different notion of **efficient**
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Distributed computing

Distributed Computing : Local model

- Different notion of **efficient**
- Time needed VS Information needed



- Can you decide locally?

Logic & Meta theorems

Problems can be expressed in **logic**. (FO, MSO,...)

The \mathcal{L} , \mathcal{C} model-checking problem:

Given $\varphi \in \mathcal{L}$ and $G \in \mathcal{C}$, does $G \models \varphi$?

Goal: **fixed parameter tractable** algorithms $O(f(\varphi) \cdot |G|^c)$

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Courcelle's Theorem (1990):

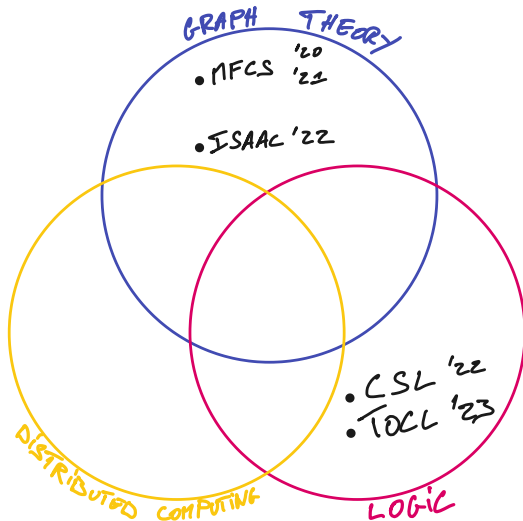
for $\varphi \in \text{MSO}$ and $\text{treewidth}(G) \leq k$, in time $O(f(\varphi, k) \cdot |G|)$

→ Generalize many known results, ex:

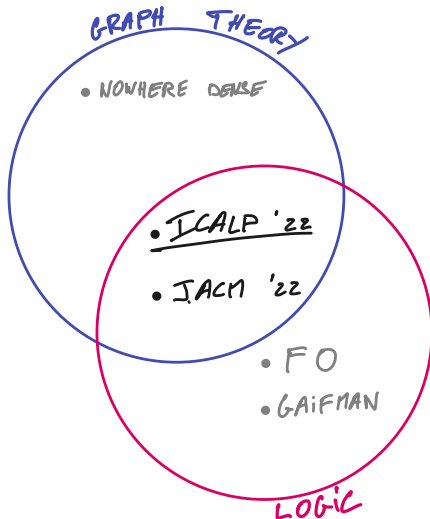
Arnborg, Proskurowski 1989:

independent sets, dominating sets, graph coloring, Hamiltonian, ...
are **linear** on **partial k -tree**.

Result overview



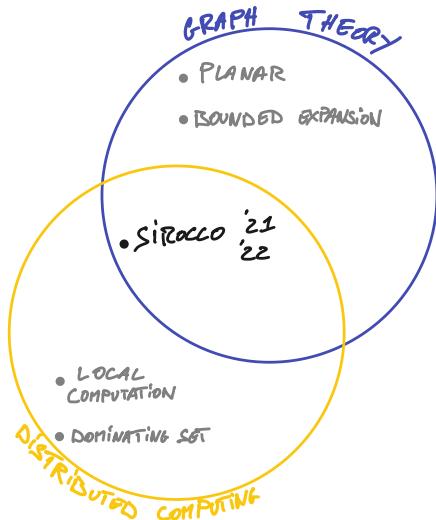
Result overview



- ENUMERATION FO QUERIES

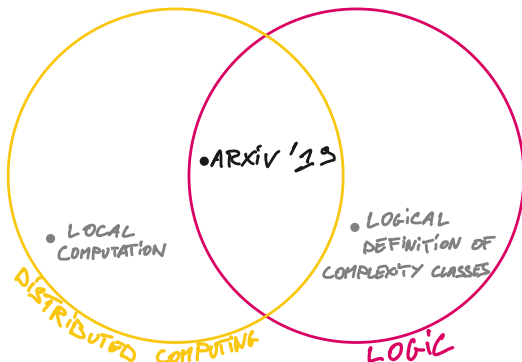
→ PODS 2018
JACM 2022

Result overview



- ENUMERATION FO QUERIES
 - PODS 2018
 - SACM 2022
- DISTRIBUTED DOMINATION ON SPARSE GRAPH CLASSES
 - SIROCCO 2021/2022
 - EUR. J. COMB. (TO APPEAR)

Result overview



- ENUMERATION FO QUERIES
→ PODS 2018
SACM 2022
- DISTRIBUTED DOMINATION
ON SPARSE GRAPH CLASSES
→ SIROCCO 2021/2022
→ EUR. J. COMB.
(TO APPEAR)
- PARAMETERIZED DISTRIBUTED
COMPLEXITY THEORY:
A LOGICAL APPROACH
→ ARXIV

Connections to AI

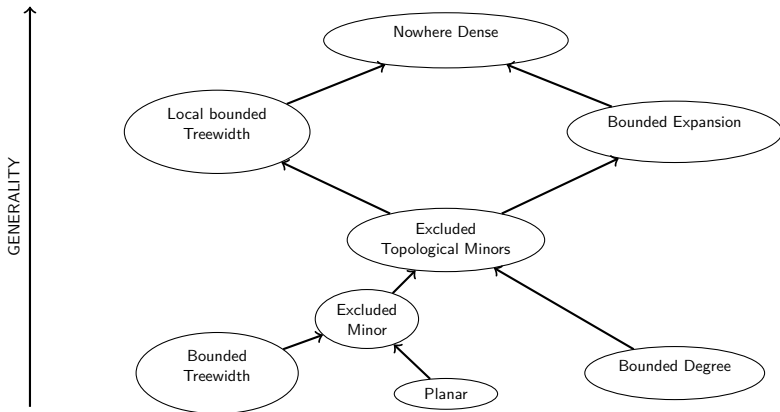
Data management

- Relational databases \leftrightarrow Colored Graphs
- Graphs in Regular Path Query, Resource Description Framework
- Logic as tool to access and describe data

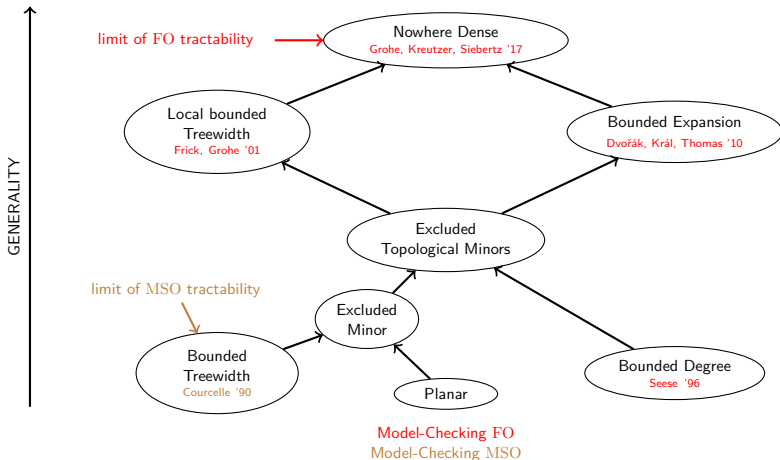
Connections distributed computing

- Local computing \sim Graph Neural Network
- Compact representation of data

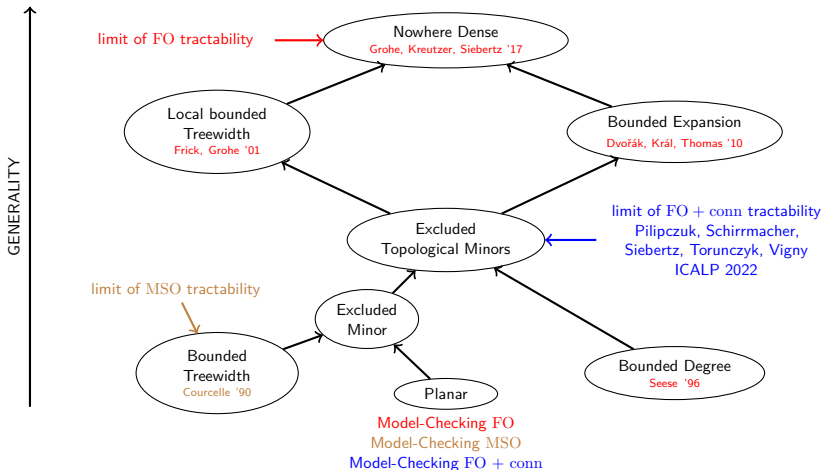
Monotone graph classes



Monotone graph classes



Monotone graph classes



FO + conn

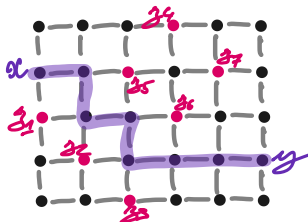
Schirrmacher, Siebertz, Vigny '21 and Bojanczyk '21

Syntax

→ Uses : FO and **conn_k**(x, y, z_1, \dots, z_k)

Meaning

→ x and y are connected after the deletion of z_1, \dots, z_k .



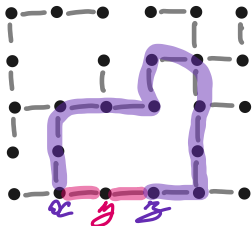
Expressive power of FO + conn

→ connectivity

$$\forall x \forall y \text{ conn}_0(x, y)$$

→ cycle

$$\varphi_{\text{cycle}} := \exists x \exists y \exists z (E(x, y) \wedge E(y, z) \wedge z \neq x \wedge \text{conn}_1(z, x, y))$$



→ Not expressible

planarity, bipartiteness, Hamiltonicity, ...

Main result

Theorem: Pilipczuk, Schirrmacher, Siebertz, Torunczyk, Vigny

- Model-checking for properties in **FO + conn** over graph classes **excluding a topological minor** is solvable in time **FPT**.
- Model-checking is **not FPT** for more general graph classes.
Under complexity assumptions

Presentation
○○

Past Research
○○○○
○○○○○

Focus
○○○○

Future and integration
●○○○
○○○

Teaching
○○○
○○

Research project

Research project

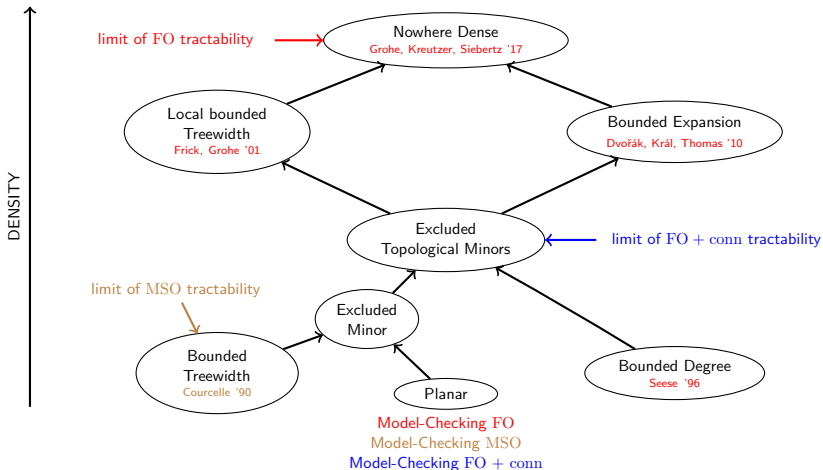
First (*short term*) goal: new logics

Beyond FO + conn

- What can be added?
- What do we want to express?
- Example: a path of even length, using only blue nodes, ...

Keeping in mind algorithmic applications

Characterization of graph classes



Directed graphs

Direction on edges

- More general
- Problems are harder
E.g. Directed Dominating Set is NP-complet on DAGs
- Some problems do not care about orientation

Reconfiguration problems

- No need to find a set
- Here, the orientation matters!

Distributed computing & Certification

Local computing

- Other notion of **efficient**
- Still looking for meta theorems

Complexity classes

- Hard problems may not be equally hard
- Define complexity classes through logic

Compact certification

- Feuilloley, Bousquet, Pierron
*What Can Be Certified Compactly? Compact local certification of **MSO** properties in **tree-like** graphs.* In PODC'22
- Fraigniaud, Montealegre, Rapaport, Todinca
A Meta-Theorem for Distributed Certification. In SIROCCO'22

Integration 1

Axe MAAD : Modèles et Algorithmes de l'Aide à la Décision *Algorithmics, Graphs, Complexity*

- M. Kanté, JF. Raymont, L. Nourine, B. Guillon
- Workshop Generalized coloring numbers (JF. Raymont)
- ANR GraphEn (M. Kanté, L. Nourine)
- Distributed computing is new.

Connections to other team:

(Axe SIC : Systèmes d'Information et de Communication)

Maxime Buron, Bruno Guillon

Integration 2

Create a logic working group with B. Guillon and M. Kanté

- Logic as tool to access and describe data
- Compact certification vs Labelling scheme (M. Kanté)

Themes

- Connection GNN \leftrightarrow Distributed computing ¹
- compact representation of data
 - Distributed computing (compact certification)
 - Property testing
 - Labelling scheme

¹A Survey on The Expressive Power of Graph Neural Networks, R. Sato 2020

Integration 3

Postdoctoral fellow

- Someone with strong AI background:
GNN, Weisfeiler-Lehman, knowledge compilation
- Working on connections GNN \leftrightarrow Local computing

PhD. Student

- Theme *Compact representation of data*
- Compact certification
- Distributed computing \sim Property testing
- Distributed computing \sim Labelling scheme

Past teaching in Paris

Around 180h

- Mainly Bachelor level
- Similar to topics in INP (ISIMA)

Subject	Years	Level	Activity
Initiation à la Programmation	2015-2016	L1	TP
Langages et Automates	2015-2016	L2	TD
Éléments d'Algorithmique	2016-2017	L2	TD
Base de données	2016-2017 2017-2018	L3 M1	TP & TD
Concepts Informatique	2017-2018	L1	TD

Past teaching in Bremen

Around 250h

- Master level
- Creation of syllabuses
- Fully in charge of a lecture

Subject	Years	Level	Activity
Finite Model Theory	2019-2020	Master	TD
Sparsity	2019-2020	Master	TD
Parametrized Complexity	2019-2020	Master	TD
Set and Model Theory	2020-2021	Master	TD
Databases, Graphs, Algorithms	2020-2021 2021-2022	Master	Cours & TD
Set and Model Theory	2021-2022	Master	Cours & TD

Highlight

Various settings

- In French, in English
- All levels
- Physical and remote

Various responsibilities

- Creation of the content
- Fully in charge of a lecture

Takeaway

- Polls
- Online white boards

Future

Possible lectures

- Most introductory lectures
- Système de gestion de base de données
- Willing to learn new theme
- ...

Cours transversal INP : *Introduction aux SGBD*

- Bonnes pratiques
- Aspect modélisation
- Introduction SQL

Future

Possible lectures

- Most introductory lectures
- Système de gestion de base de données
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Cours transversal INP : *Introduction aux SGBD*

- Bonnes pratiques
- Aspect modélisation
- Introduction SQL

Responsibilities

- Responsable d'années
- Stages
- ...

Thank you!

- 2019-2023: Postdoc, University of Bremen. With Sebastian Siebertz
- 2018-2019: Postdoc, University of Warsaw. With Szymon Toruńczyk
& Mikołaj Bojańczyk
- 2015-2018: Thesis, University Paris Diderot. With Arnaud Durand
& Luc Segoufin

Info:

- 1 Journal: J.ACM (TOCL & Eur. J. Comb. to appear)
- 9 Conferences: ICDT, PODS, MFCSx2, SIROCCOx2, ISSAC, CSL, ICALP.
- 1 Workshop (co-organizer): <https://podc-dare.github.io/>.
- 1 Popularization: La gazette du GDR-IM.

tinyurl.com/short-polls

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