Audition MCF 108

Alexandre Vigny

https://alexandre-vigny.github.io/mcf108.pdf

May 12, 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)
  $\sim$ 180h
- → In Bremen (3 years)
  $\sim$ 270h

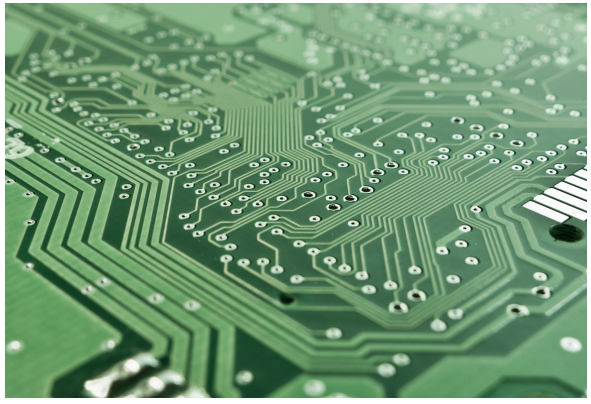
Highlights

- → 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?"

$\rightarrow$ Is G planar?

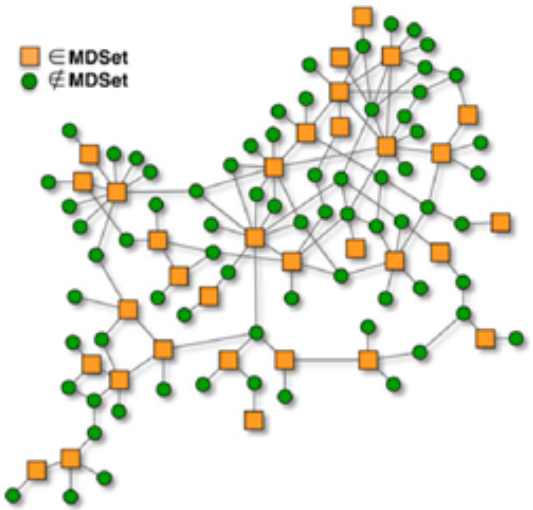


Algorithmic graph theory

Given a graph G and a property P: "Does G satisfy P?"

$\rightarrow$ Is G planar?

$\rightarrow$ 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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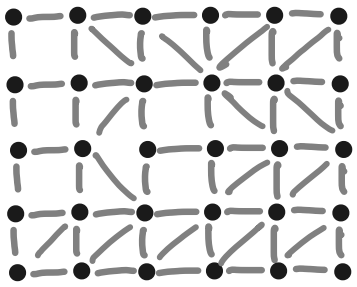
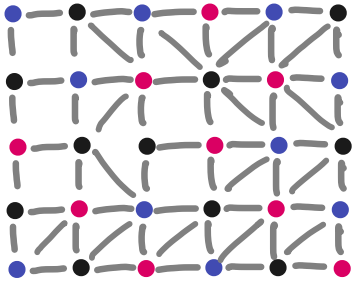
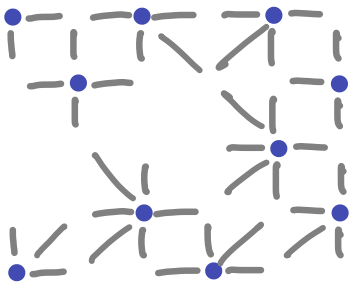
Monadic second-order (MSO) logic

→ 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

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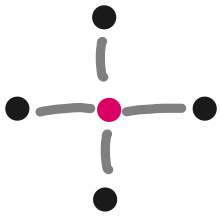

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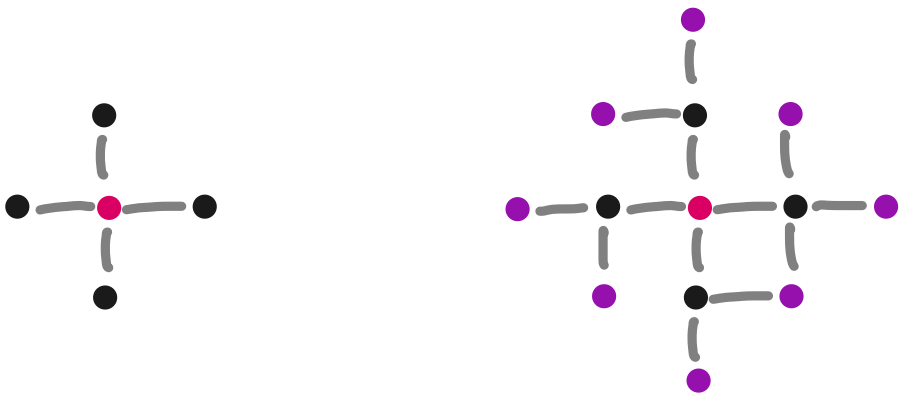

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Distributed Computing : Local model

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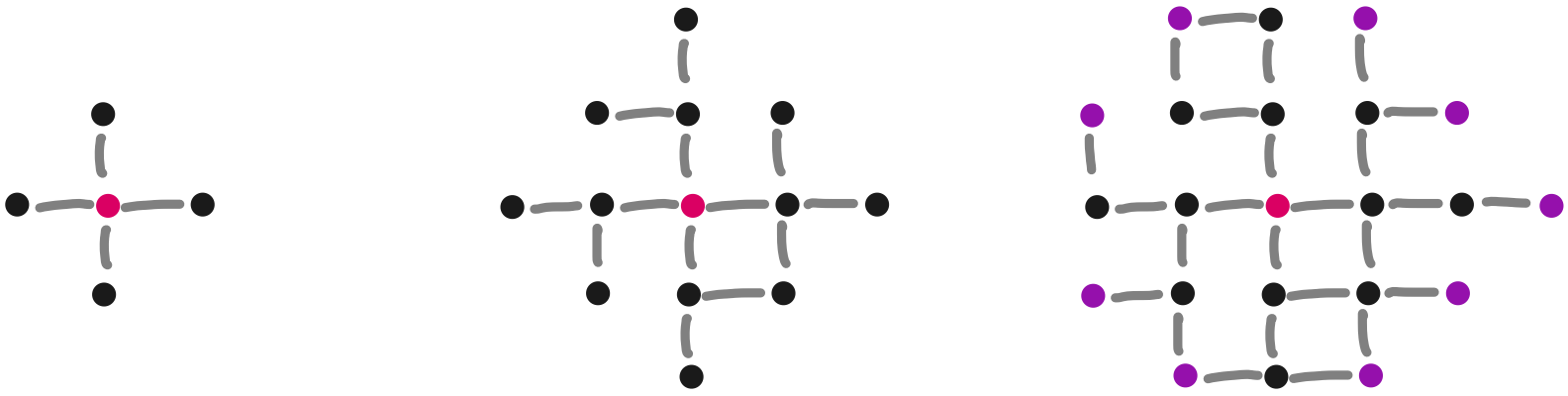

→ Can you decide locally?

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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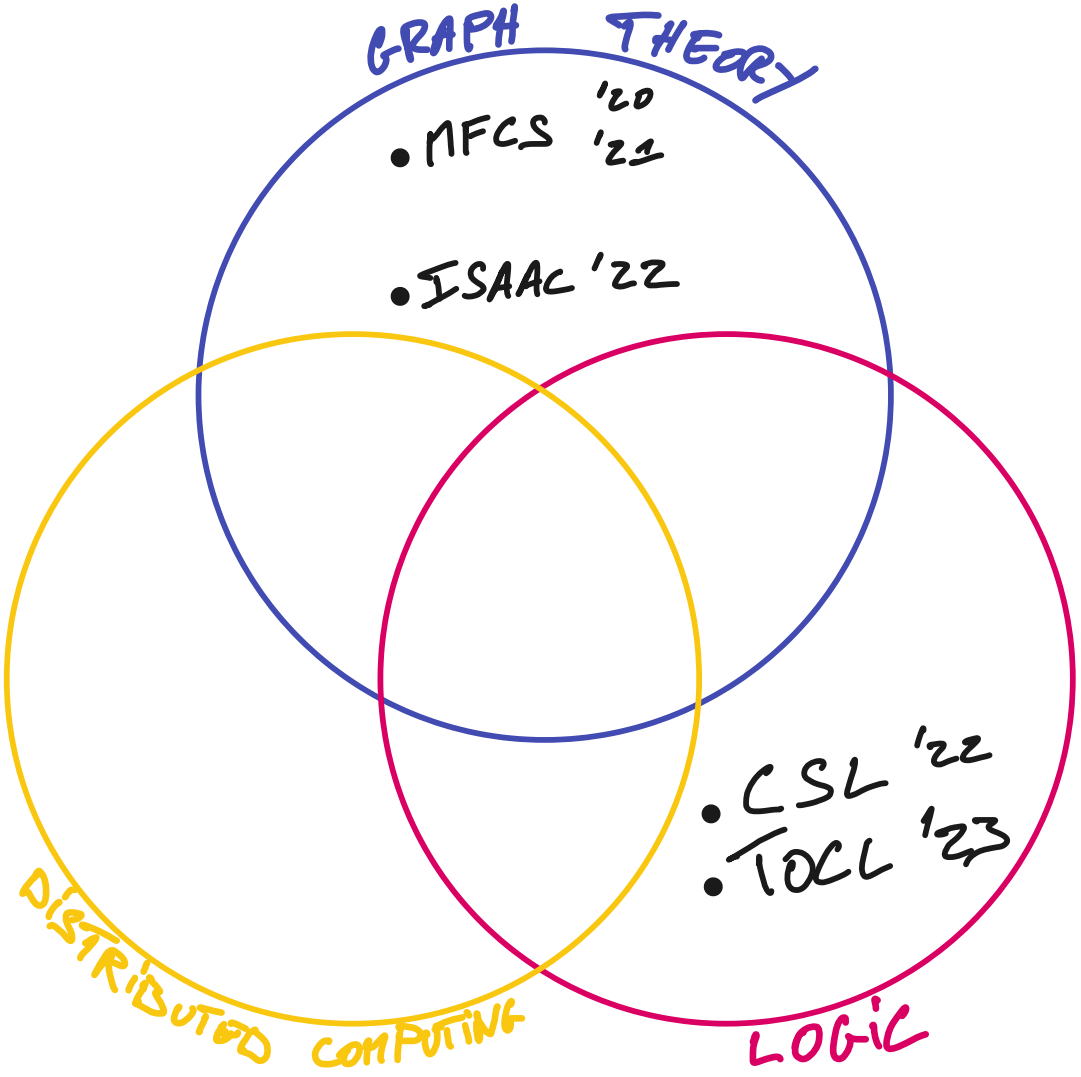
Courcelle's Theorem (1990):
for $\varphi \in \mathrm{MSO}$ and treewidth$(G) \leq k$, in time $O(f(\varphi, k) \cdot |G|)$

$\rightarrow$ Generalize many known results, ex:
Arnborg, Proskurowski 1989:
independent sets, dominating sets, graph coloring, Hamiltonian, ...
are linear on partial k-tree.

Result overview



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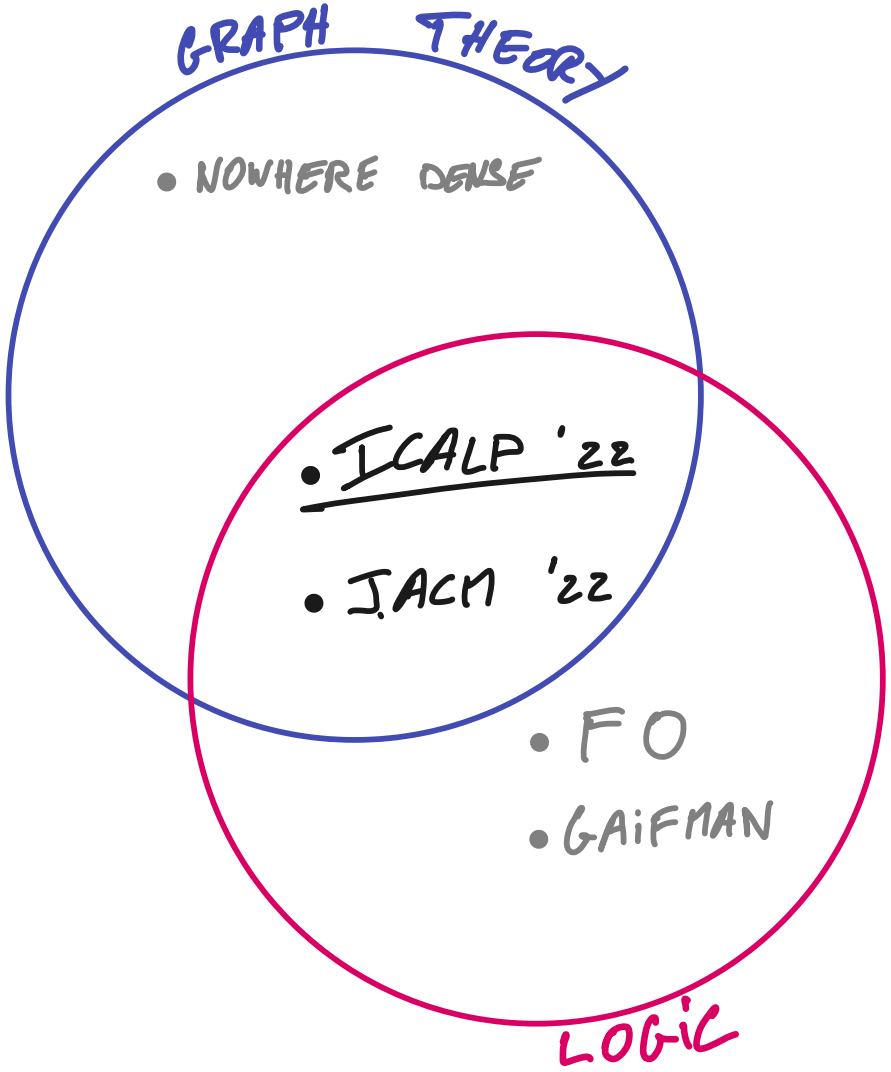

- ENUMERATION FO QUERIES
  -> PODS 2018
  JACM 2022

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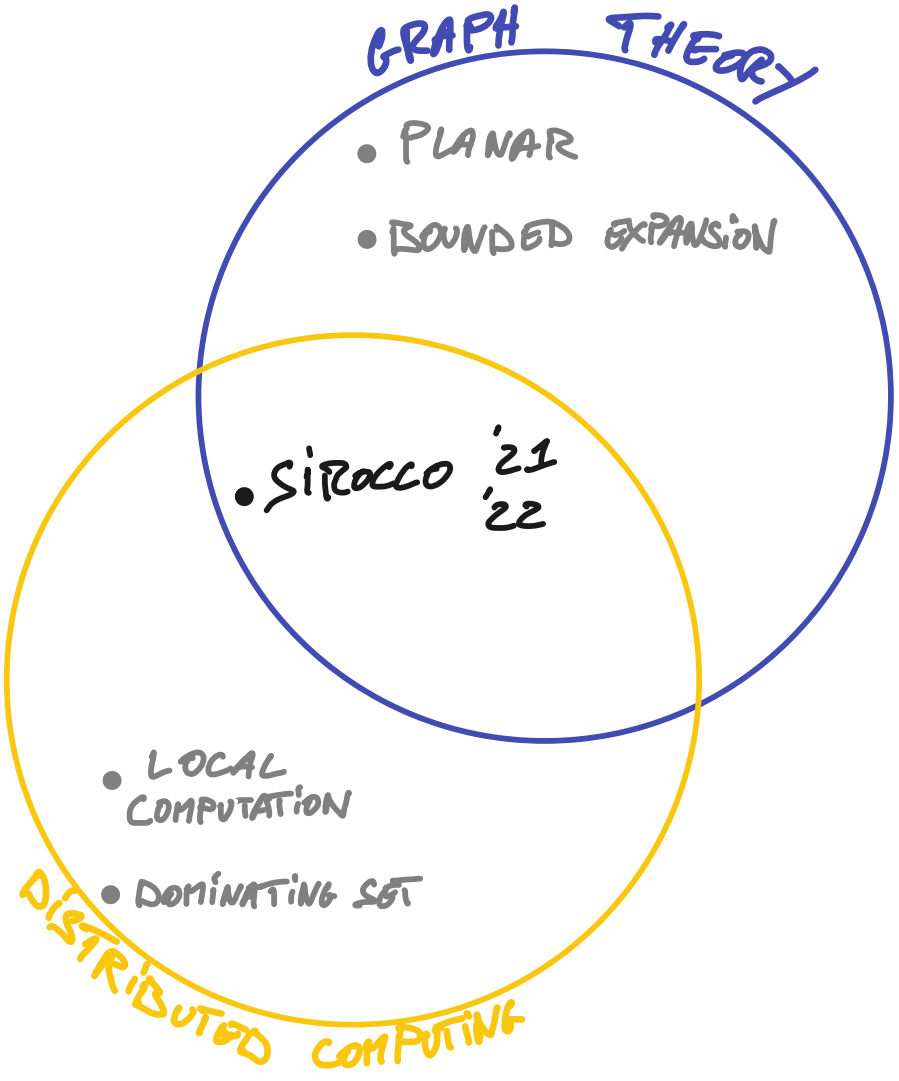

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  - -> EUR. J. COMB. (TO APPEAR)

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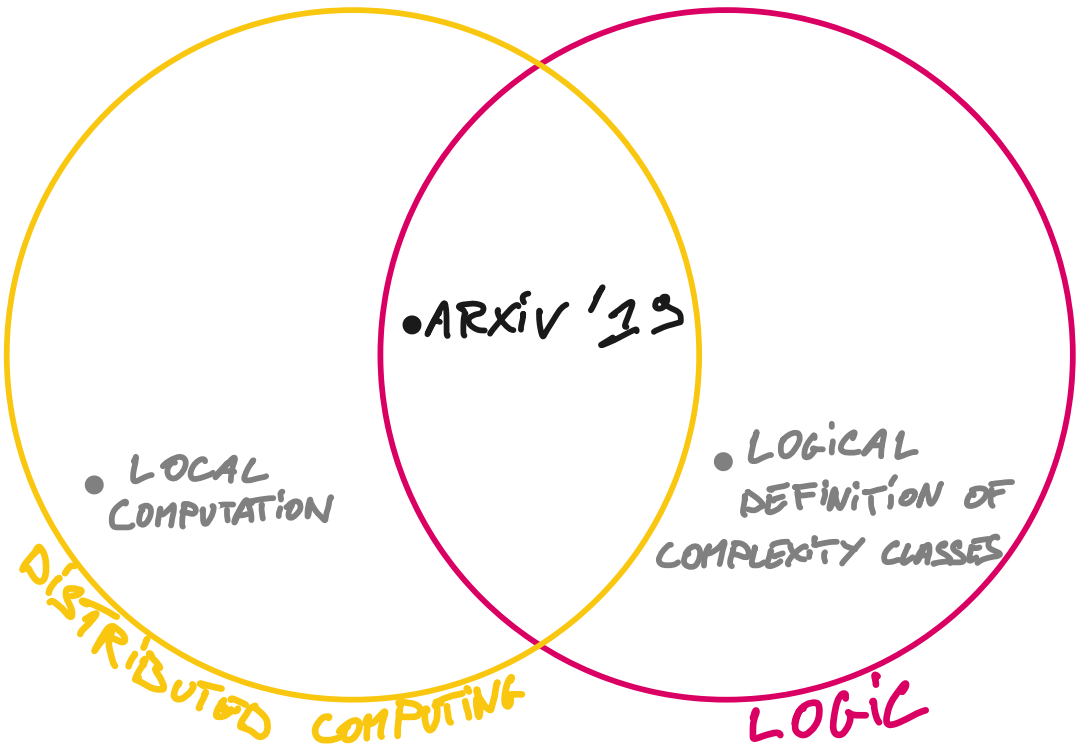

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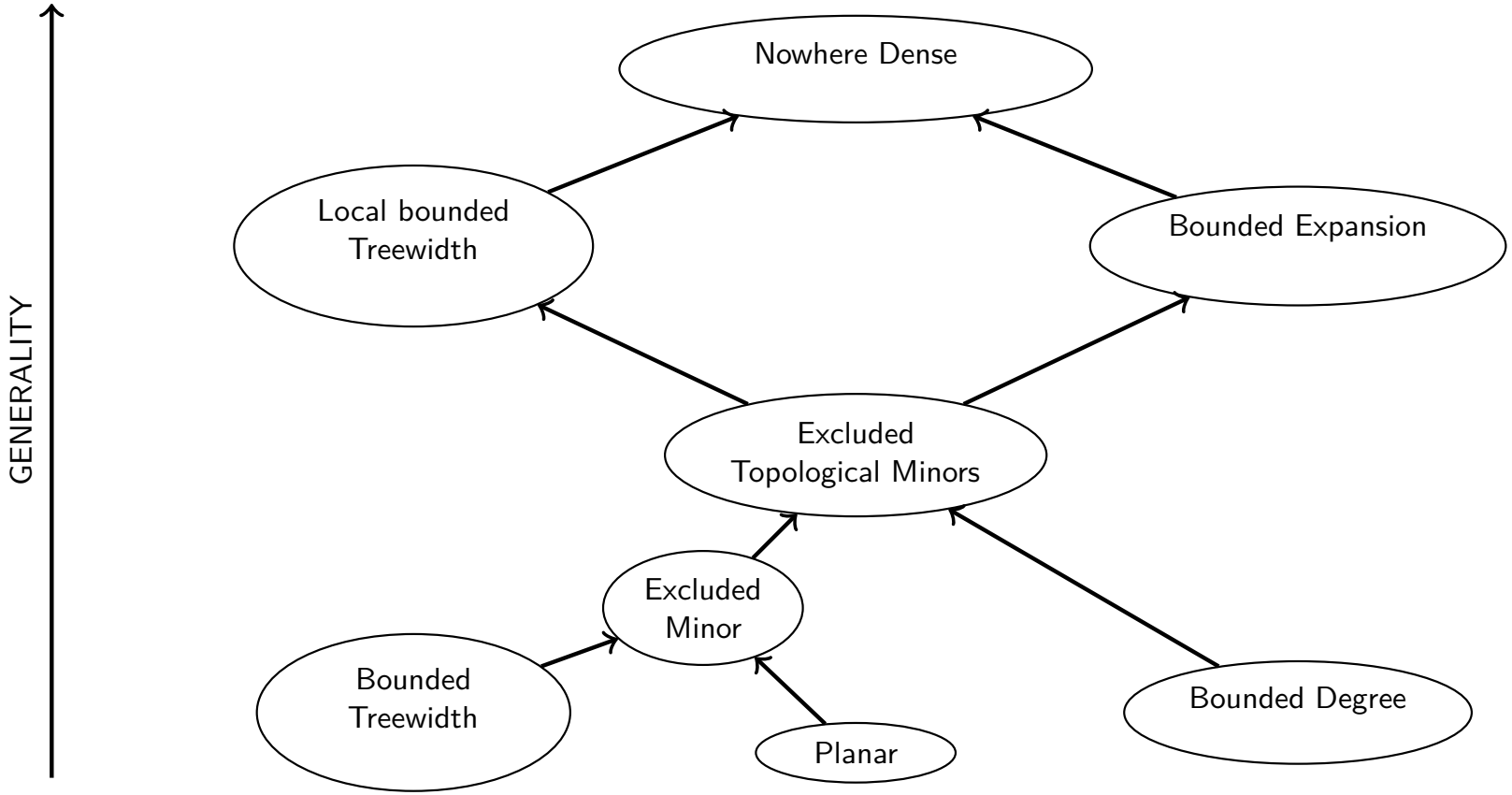
- PARAMETERIZED DISTRIBUTED COMPLEXITY THEORY : A LOGICAL APPROACH
  - -> ARXIV

Monotone graph classes



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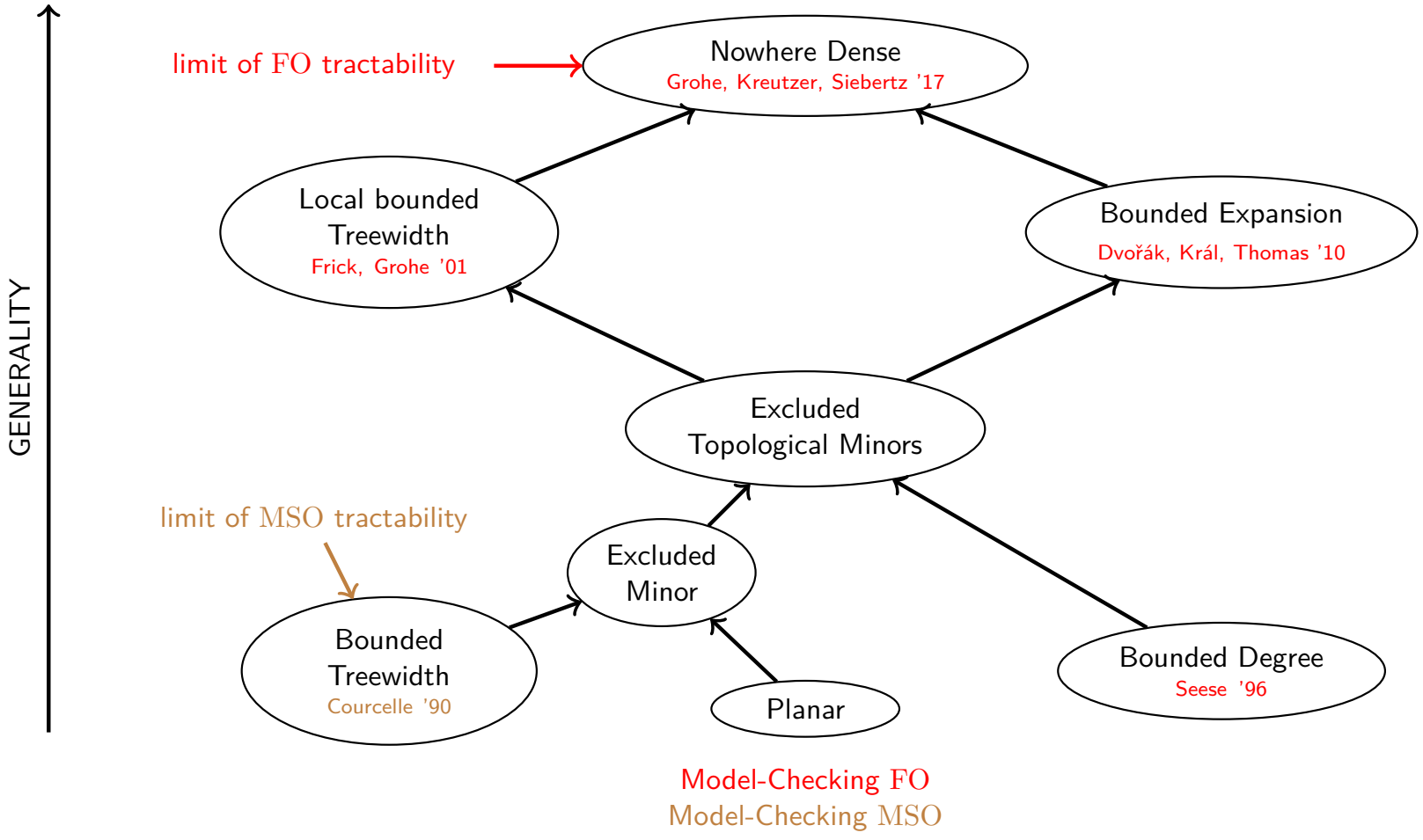

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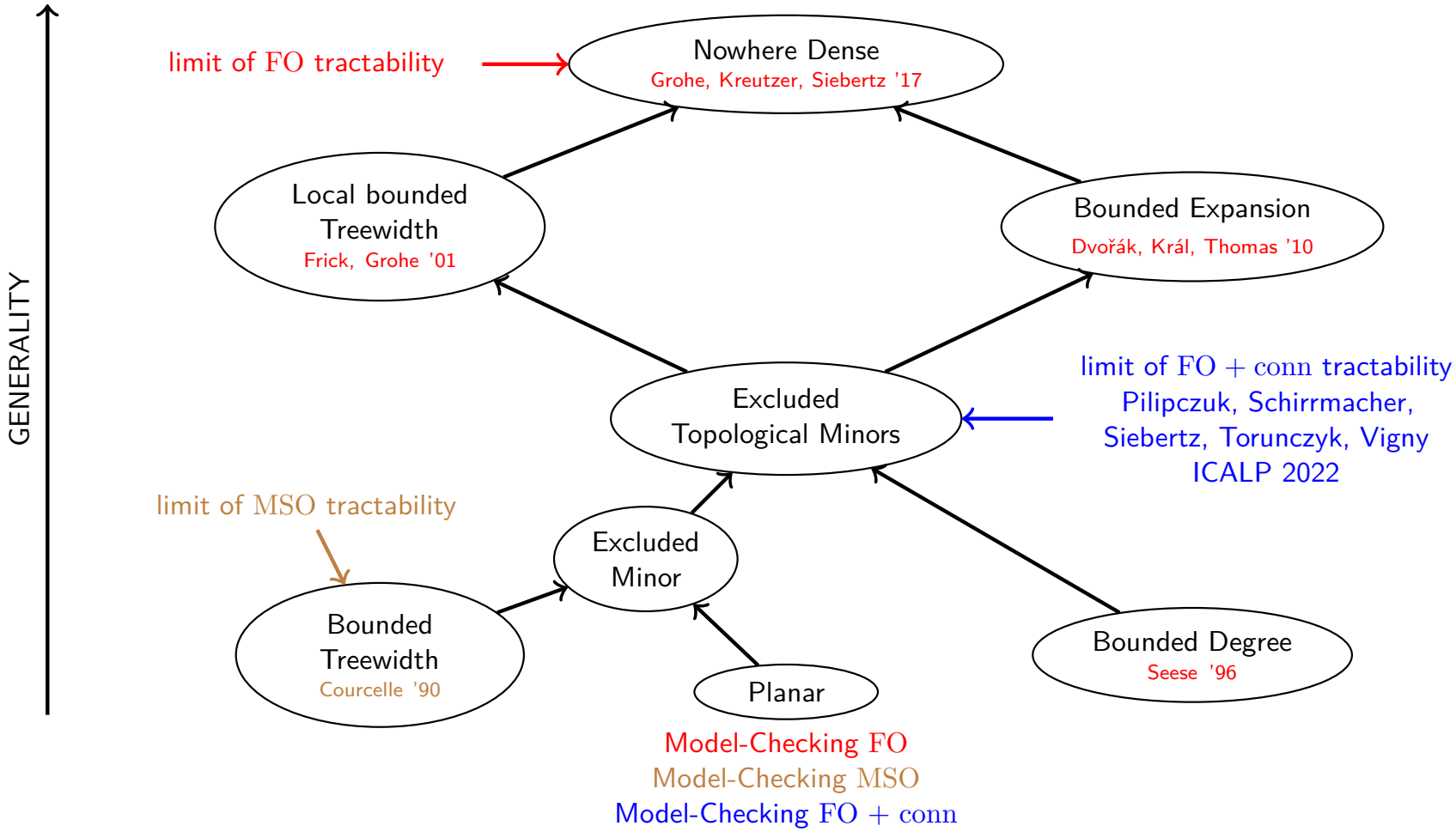


FO + conn

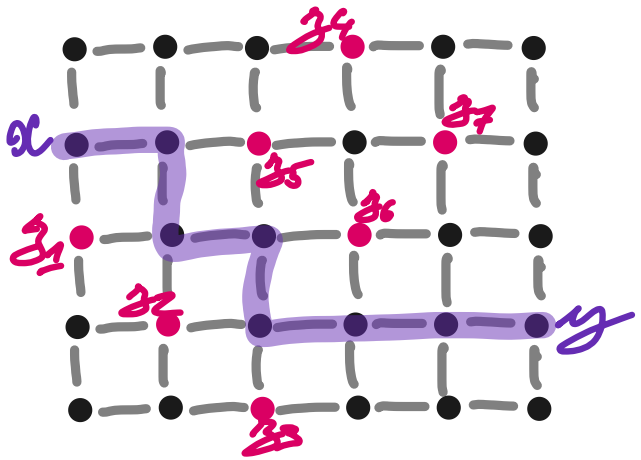
Schirrmacher, Siebertz, Vigny '21 and Bojanczyk '21

Syntax

→ Uses : FO and $\mathbf{conn}_k(x, y, z_1, \ldots, z_k)$

Meaning

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



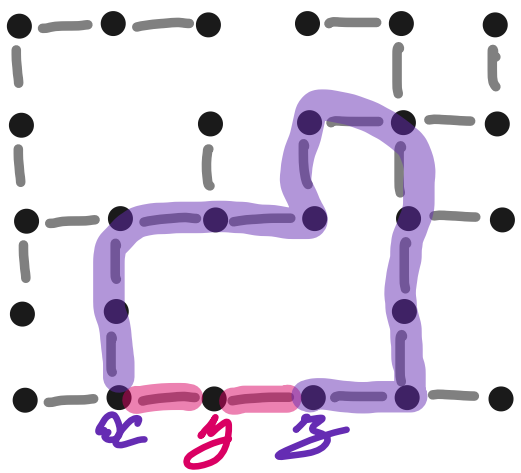
Expressive power of FO + conn

→ connectivity

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

→ cycle

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



→ Not expressible

planarity, bipartiteness, Hamiltonicity, ...

Main result

Theorem: Pilipczuk, Schirrmacher, Siebertz, Torunczyk, Vigny

→ Model-checking for properties in $\mathrm{FO} + \mathrm{conn}$ 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

Research project

Research project

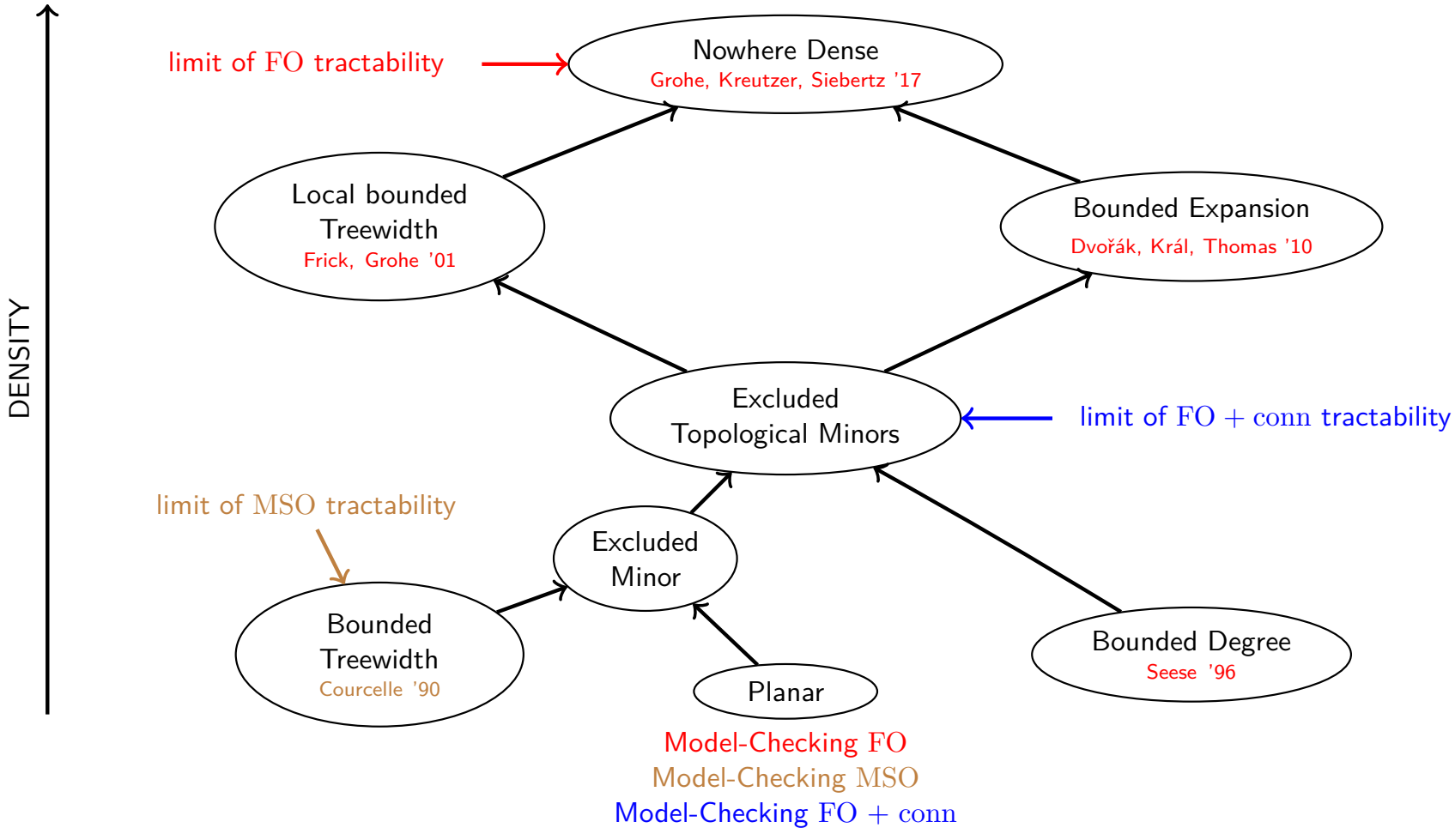
First *(short term)* goal: new logics

Beyond $\mathrm{FO} + \mathrm{conn}$

- → 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

Algorithmes, Graphes et Combinatoire (AlGCo)

- → D. Thilikos, I. Sau, G. Stamoulis
- → Compound logic - $\mathrm{FO} + \mathrm{conn}$
  Structural graph theory & Graph decomposition - Robust logic framework
- → ANR JCJC of I. Sau *Exploring the Limits of Tractability*.
  Contribution on directed tree-width.
- → Adding logic to the team

Past teaching in Paris

Around 180h

→ Mainly Bachelor level

→ Similar to topics in Faculté des Sciences

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 1

L1:

- → Algorithmique 1, 2
- → Remise a niveau en Python
- → Jouons aux automates déterministes

L2:

- → Algorithmique 3
- → Systèmes d'information & conception de BDD
- → Logique propositionnelle
- → POO

L3:

- → Algorithmique 4
- → Logique du premier ordre
- → Systèmes d'information & conception de BDD 2
- → Complexité, calculabilité, décidabilité

Future 2

Master

→ Parcours Algorithmique
- Graphes, structures et algorithmes
- Logique, calculabilité et complexité
- Algorithmique avancée / spécialisée
- Calculabilité
- Graphes, algorithmique et complexité

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

back