

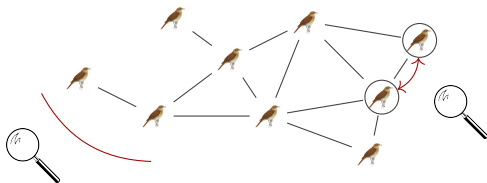
# Projet ANR TEMPOGRAL

Réunion de lancement  
(Chasseneuil-du-Poitou)

Arnaud Casteigts

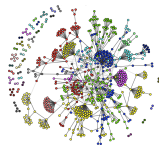
24 novembre 2022

# Networks / Graphs



Network as **data**

→ **centralized** algorithms...



Network as an **environment**

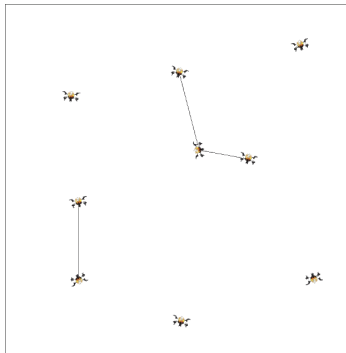
→ **distributed** algorithms...



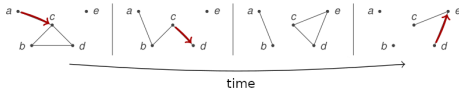
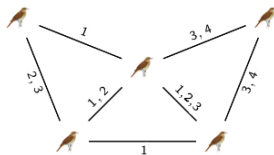
# (Highly) dynamic networks ?



Example of scenario



## Modeling



Properties :

- ▶ Temporal connectivity ?
- ▶ Repeatedly ?
- ▶ Recurrent links ?
- ▶ In bounded time ?
- ▶ ...

$TC$

$TC^R$

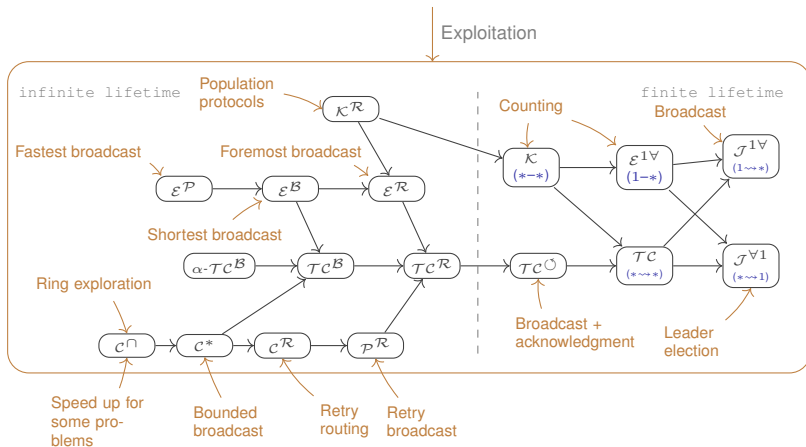
$\mathcal{E}^R$

$\mathcal{E}^B$

→ Classes of temporal graphs

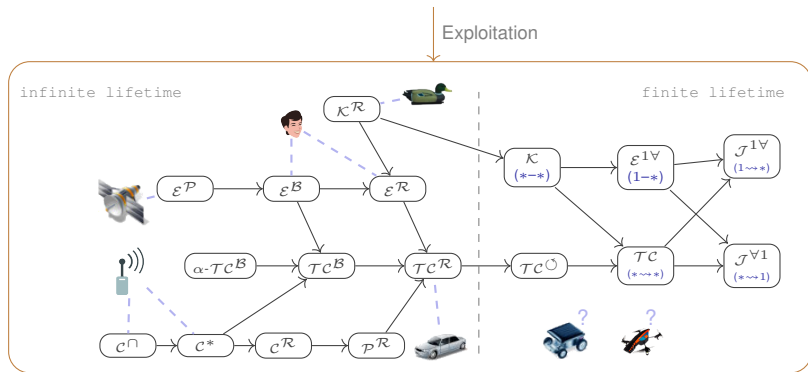
# Some classes of temporal graphs

## Distributed algorithm



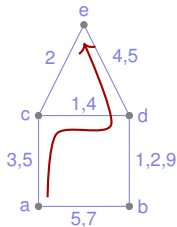
# Some classes of temporal graphs

## Distributed algorithm



## TEMPOGRAL Project

### Temporal graphs algorithms (for their own sake)



#### Fundamental questions :

- What makes temporal graphs different ?
- Why are temporal problems harder ?
- BTW, what is a "temporal" problem ?

...

# Basic definitions

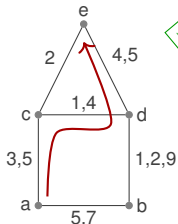
Temporal graphs

(a.k.a. time-varying, time-dependent, evolving, dynamic,...)

$\mathcal{G} = (\underline{V}, \underline{E}, \lambda)$ , where  $\lambda : E \rightarrow 2^{\mathbb{N}}$  assigns *presence times* to edges.

⊥  
*footprint* of  $\mathcal{G}$

Example :



Can also be viewed as a sequence of *snapshots*  $\{G_i = \{e \in E : i \in \lambda(e)\}\}$

Temporally connected

## Temporal paths

- ▶ Non-strict - ex :  $\langle (a, c, 3), (c, d, 4), (d, e, 4) \rangle$  (non-decreasing)
- ▶ Strict - ex :  $\langle (a, c, 3), (c, d, 4), (d, e, 5) \rangle$  (increasing)

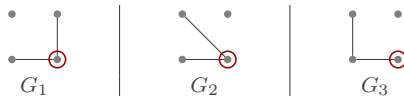
*Temporal connectivity* :  $\exists$  temporal paths between all vertices.

→ Warning : Reachability is non-symmetrical... and **non-transitive** !

# Re-definition of problems (1)

## Different adaptations of a problem

E.g. : Covering problems like DOMINATINGSET



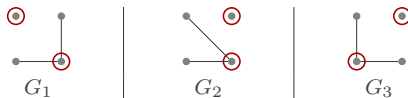
→ *Temporal variant*



# Re-definition of problems (1)

## Different adaptations of a problem

E.g. : Covering problems like DOMINATINGSET



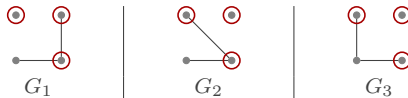
→ *Temporal variant*

→ *Evolving variant* (a.k.a. "dynamic graph algorithms")

# Re-definition of problems (1)

## Different adaptations of a problem

E.g. : Covering problems like DOMINATINGSET



→ *Temporal* variant

→ *Evolving* variant (a.k.a. "dynamic graph algorithms")

→ *Permanent* variant

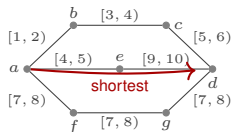
$PermanentDS \supseteq EvolvingDS_i \supseteq TemporalDS$ .

Note : Permanent version not appropriate for all problems...

# Re-definition of problems

## Broadcast ?

[Bui-Xuan, Ferreira, Jarry, 2003]



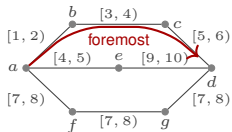
Which way is optimal from  $a$  to  $d$ ?

-min hop ?

# Re-definition of problems

## Broadcast ?

[Bui-Xuan, Ferreira, Jarry, 2003]



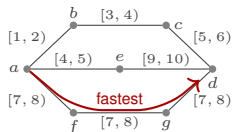
Which way is optimal from  $a$  to  $d$ ?

- min hop ?
- earliest arrival ?

# Re-definition of problems

## Broadcast ?

[Bui-Xuan, Ferreira, Jarry, 2003]



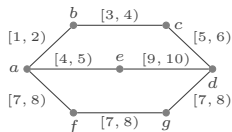
Which way is optimal from  $a$  to  $d$ ?

- min hop ?
- earliest arrival ?
- fastest traversal ?

# Re-definition of problems

## Broadcast ?

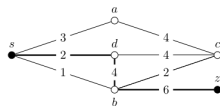
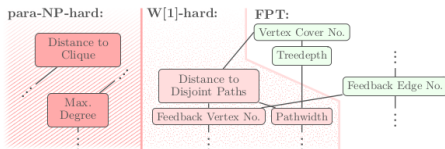
[Bui-Xuan, Ferreira, Jarry, 2003]



Which way is optimal from  $a$  to  $d$ ?

- min hop ?
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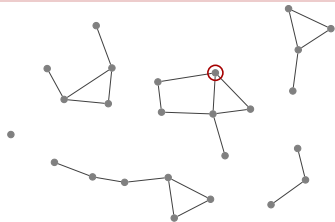
## Temporal paths under waiting time constraints



(with A. Himmel, H. Molter, P. Zschoche)

## Re-definition of problems (3)

Ex : ELECTION, SPANNINGTREE, ...



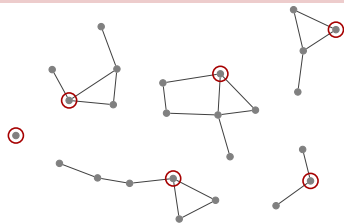
How are they defined ?

→ Several options

- ▶ One global leader, elected once and forever

## Re-definition of problems (3)

Ex : ELECTION, SPANNINGTREE, ...



How are they defined ?

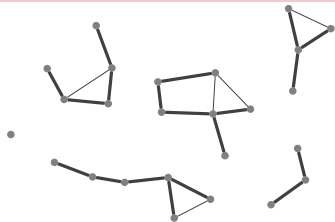
→ Several options

- ▶ One global leader, elected once and forever
- ▶ One leader per component, changing as the graph changes



## Re-definition of problems (3)

Ex : ELECTION, SPANNINGTREE, ...



How are they defined ?

→ Several options

- ▶ One global leader, elected once and forever
- ▶ One leader per component, changing as the graph changes

Both are very different in essence !

# Main axes and themes

The project focuses on three main *axes* (semantically equivalent to workpackages), namely “Classification of temporal problems” (C), “Tractability of temporal problems” (T), and “Algorithmic tools” (A). Each axis consists of three or four interconnected research *themes* (semantically equivalent to tasks):

- C1.** What makes a problem intrinsically temporal? How to characterize temporality? p 3
- C2.** Problems defined by the search for temporal substructures p 3
- C3.** Temporal versions of optimization problems on graphs p 4
- C4.** Problems related to the generation of temporal graphs p 5
  
- T1.** Restricting the snapshot or the underlying graph and corresponding parameters p 6
- T2.** Hierarchies of temporal graph classes p 7
- T3.** Forbidden temporal patterns vs. tractability p 8
  
- A1.** Design of advanced data structures p 10
- A2.** Generation of temporal graphs p 11
- A3.** Specifically designed algorithms for temporal problems p 12

(<https://www.labri.fr/perso/acasteig/tempogral/tempogral.pdf>)

# Partners

Partner	Name	First Name	Position	Involv.	Themes	Coord.
LaBRI/ U. Bordeaux	<b>Casteigts</b>	<b>Arnaud</b>	<b>MCF HDR</b>	<b>30</b>	C1,C2,T1,T2,A2,A3	<b>Global</b>
	Corsini	Timothée	PhD std (MESR)	25	C2,T3,A3	
	Gavoille	Cyril	PR	16	C2,T3,A1	
	Hanusse	Nicolas	DR CNRS	15	C1,C3,T1,A1	
	Klasing	Ralf	DR CNRS	18	C1-C3,T1,A3	
	Johnen	Colette	PR	16	C3,T2,A3	
			PhD student	36	C2,T1,T2,A3	
LITIS/ U. Le Havre Normandie	Balev	Stefan	MC	16	C3,C4,A2,A3	
	Guinand	Frédéric	PR	11	C1,C4,A2,A3	
	Pigné	Yoann	MC	11	C2,C4,A2,A3	
	<b>Sanlaville</b>	<b>Eric</b>	<b>PR</b>	<b>24</b>	C1,C3,T1,T2,A3	<b>Local</b>
	Vernet	Mathilde	MC	12	C1,C3,T2,A3	
		PhD student	36	C1,C3,A3		
IRIF/ U. Paris Cité	Habib	Michel	PR Em.	15	C2,T2,T3,A3	
	de Montgolfier	Fabien	MCF	18	C2,T1,A3	
	Naserasr	Reza	CR CNRS	15	C1,C3,T1,T3,A3	
	Rabie	Mikaël	MCF	20	C1,T2,A1,A3	
	<b>Viennot</b>	<b>Laurent</b>	<b>DR INRIA</b>	<b>27</b>	C2,C4,T2,A1,A3	<b>Local</b>
		Post Doc	12	C1,T1,T2,A3		

(<https://www.labri.fr/perso/acasteig/tempogral/tempogral.pdf>)

# Summary of the talks (today and tomorrow)

## Dynamic/Temporal versions of :

- ▶ Autostabilization (Colette)
- ▶ Connected components (Jason)
- ▶ Flows (Mathilde)
- ▶ Coloring (Minh Hang)
- ▶ Property testing (Ralf)
- ▶ Generation (Vincent)

## Topics without static analogs :

- ▶ Temporalisation (Laurent)
- ▶ Waiting constraints (Filippo)
- ▶ Expressivity of temporal graphs (Timothée)

## Other related topics (graphs and/or mobility) :

- ▶ Graph classes based on patterns (Michel)
- ▶ Data structures for mobile networks (Nicolas)
- ▶ Robots in the plane (Cyril)

**+ Open problem session, tomorrow at 11am.**