INSTITUT
DE RECHERCHE
EN INFORMATIQUE
FONDAMENTALE

Université
Paris Cité

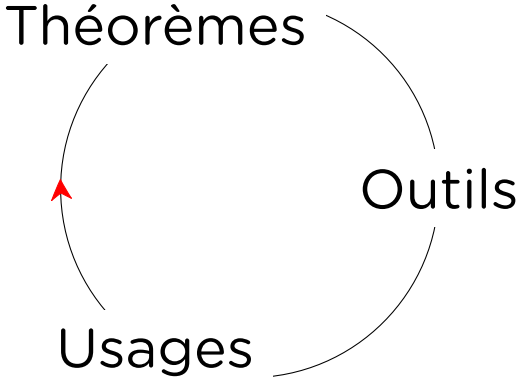
cnrs Inria

Équipe Analyse et Conception de Systèmes

Responsables : Pierre-Évariste Dagand (2021-2024)
Ralf Treinen (2017-2021)

7,2 permanents : 1 PR, 3,2 MC, 1,2 DR, 1,8 CR
1,7 ATER, 0 PostDoc, 5,8 Doc, 0,5 Émérites
Total : 16,2 membres

Thématiques et enjeux



Thématiques et enjeux

Logiciel d'infrastructure

(verif)

- Protocole de routage Babel (Juliusz Chroboczek)
- Projet CoLiS (Ralf Treinen)
- Community-coq (Théo Zimmermann*)

Systèmes concurrents

(algebre, verif)

- Système de Markov concurrent (Samy Abbes)
- Préordres de tests (Giovanni Bernardi)
- Réseaux booléens asynchrones (Paul Ruet)

Thématiques et enjeux

Langages de programmation (algebre)

- Types ensemblistes (Giuseppe Castagna)
- Types gardés (Adrien Guatto)

Assistant de preuve Coq (algebre, preuves)

- Coq & MetaCoq (Matthieu Sozeau*)
- Expressions régulières certifiées (Pierre Letouzey)
- Interpolants uniformes certifiés (Hugo Férée)

Thématiques et enjeux

Paradigmes émergents

(preuves)

- Ingénierie des preuves à grande échelle (Emilio J. Gallego)
- Réseaux d'interaction (Jean Krivine*)
- Programmes incrémentaux (Yann Régis-Gianas*)

Enseignement & Société

- Notes "Outils Logiques"[1], *etc.* (Roberto Amadio)
- Initiative de Recherche et Innovation sur le Logiciel Libre (Roberto Di Cosmo*)

1. `https://cel.hal.science/cel-00163821/`

Vie et organisation

Animation scientifique

- Séminaire pôle PPS
- Groupe de travail Programmation
- Séminaire IRILL

Évolution thématique

- Promotions : S. Zacchiroli(PU), T. Zimmerman(MCF)
- Disponibilités : Y. Régis-Gianas(MCF), J. Krivine(CR)
- Départ : M. Sozeau(CR)
- Arrivées : H. Férée(MCF), A. Guatto(MCF), P.-E. Dagand(CR), G. Baudart(CR), G. Scherer(CR), J. Krivine(CR)

Projection

Programmes

- Conception de langages
- Programmation certifiée
- Documents mathématiques interactifs

Systèmes

- Systèmes concurrents
- Systèmes biologiques
- Protocole de routage Babel

Responsable : Jean Krivine (2024)

Besoins

Actualisation de la ligne scientifique

- Porteuse de sens collectif
- Attractivité nationale & internationale
- Positionnement GAFAM & start-up

Recrutement rang A

- Rééquilibrage : 5 rangs B / 7,2 permanents
- Actualisation scientifique
- Accompagnement rangs B

Scientific focus :
Concurrent probabilistic systems

Samy Abbes

Équipe ACS — Évaluation HCERES, 29 novembre 2023

Framework: the partial order semantics for concurrency

A stateless model

- An alphabet Σ of actions
- Some pairs of actions are declared concurrent

$$a \text{ and } b \text{ are concurrent} \iff (a, b) \in I$$

$$I \subseteq \Sigma \times \Sigma \quad I \text{ is symmetric and irreflexive}$$

- Executions of the system are *words up to commutation of contiguous concurrent actions*

i.e., elements of the trace monoid: $\mathcal{M} = \Sigma^* / \mathscr{R}$

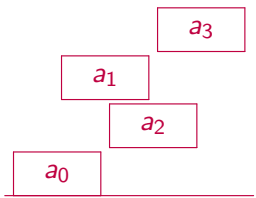
where $\mathscr{R}$ is the congruence on Σ^* generated by I

Framework: the partial order semantics for concurrency

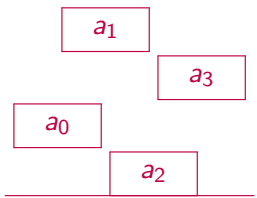
Example: the dimer model

$$\Sigma = \{a_0, \ldots, a_3\} \qquad (a_i, a_j) \in I \iff |i-j| > 1$$

word $a_0\, a_2\, a_1\, a_3$

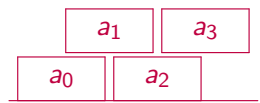


word $a_2\, a_0\, a_3\, a_1$



trace

$a_0 \cdot a_2 \cdot a_1 \cdot a_3 = a_2 \cdot a_0 \cdot a_3 \cdot a_1$



Framework: the partial order semantics for concurrency

More realistic: state models

- Defined by the action of a trace monoid $\mathcal{M}$ on a finite set X of states with an absorbing sink state $\perp$

$$X \times \mathcal{M} \to X \qquad (\alpha \cdot x) \cdot y = \alpha \cdot (x \cdot y) \qquad \perp \cdot x = \perp$$

- For each state $\alpha \in X$:

$$\mathcal{M}_\alpha = \{x \in \mathcal{M} \ : \ \alpha \cdot x \neq \perp\}$$

  is the set of trajectories of the system starting from α
- **Example :** a bounded Petri with X as the set of markings and $\mathcal{M}$ is generated by the transitions of the net

Probabilistic questions

General questions

- Are there natural probabilistic layers for concurrent trajectories of size n ?
- Are there natural probabilistic layers for infinite concurrent trajectories ?
  - What are the probabilistic parameters ?
  - What are the probabilistic properties ?
- For applications: is there a convergence of k-size layers for finite trajectories toward the probabilistic layer for infinite trajectories ?

Some answers

Stateless models: trace monoids

- **Without concurrency:** memoryless measures on infinite words with $|\Sigma| = n$ are parametrized by the $(n-1)$-dimensional simplex

$$\forall i \in \{1, \dots, n\} \quad p_i \geq 0 \qquad\qquad p_1 + \cdots + p_n = 1$$

- **With concurrency:** memoryless measures on infinite traces with $|\Sigma| = n$ **do exist** and are parametrized by an algebraic closed surface of the following form

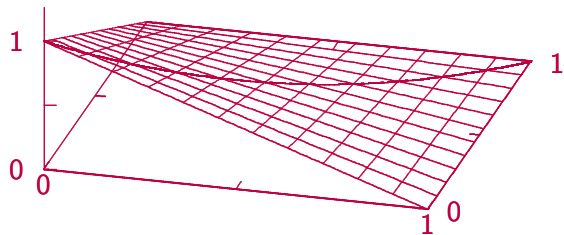
$$\forall i \in \{1, \dots, n\} \quad \underbrace{h_i(p_1, \dots, p_n)}_{\substack{\text{polynomial} \\ \text{of degree} < d}} \geq 0 \qquad\qquad \underbrace{h_0(p_1, \dots, p_n)}_{\substack{\text{polynomial} \\ \text{of degree } d}} = 0$$

where d is the highest concurrency degree of the monoid

Some answers

Graphical representation of the probabilistic parameters in (p_0, p_1, p_2)-space for the 3-slots dimer model

$\Sigma = \{a_0, a_1, a_2\}$ $\quad a_0 a_2 = a_2 a_0$ $\quad \boxed{1 - p_0 - p_1 - p_2 + p_0 p_2 = 0}$



There is a unique solution where all parameters are equal, which defines the unique **uniform** measure on infinite traces

Some answers

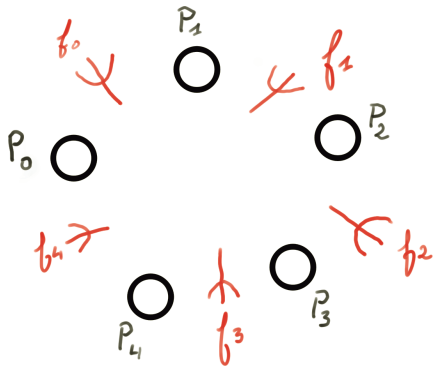
Application: computing the average parallelism in a trace monoid

$$\begin{aligned}\tau(x) &= \text{concurrency rate of the finite trajectory } x \\ &= \frac{\text{minimal number of rounds to execute } x}{|x|} \\ \tau_n(\mathcal{M}) &= \text{average of } \tau_x \text{ for } x \in \mathcal{M} \text{ and } |x| = n \\ \tau_{\mathcal{M}} &= \lim_{n \to +\infty} \tau_n(\mathcal{M})\end{aligned}$$

Thanks to the **uniform measure**, $\tau_{\mathcal{M}}$ can be computed by an explicit formula depending on the coefficients of the Möbius polynomial of the monoid $\mathcal{M}$ (number of concurrency cliques of siez $0, 1, \ldots$)

Some answers

The 5-philosophers/5-forks model: an example with states



In an endless play:
p = probability for philosopher P_0 to grab the two forks f_0 and f_4 and start eating

$$p = \frac{5 - \sqrt{5}}{10} \approx 0.2764 > 0.2$$

The randomization is Markovian rather than memoryless

Résumé synthétique

Équipe Analyse et Conception de Systèmes (ACS)

- 16,2 membres dont 7,2 permanents
- 1 groupe de travail régulier & séminaire PPS
- Projets structurants : ANR Asesyc, CoLiS, DCore, Rapido ; Inria Picube
- 29,67 articles de journaux (pro-rata)
- 40,5 articles de conférences (pro-rata)
- 67 publications communes avec PP
- 16 projets de logiciel libre
- 8,17 thèses (2 prix de thèse GDR GPL)
- Prix Science Ouverte du Logiciel Libre pour Coq
- Test of Time Award (Concur)