2024

13th Confluence Competition

Raúl Gutiérrez **Aart Middeldorp** Naoki Nishida
Teppei Saito René Thiemann

https://project-coco.uibk.ac.at/2024

Outline

1. **Acknowledgements**
2. **History**
3. **2024**
4. **Awards**
5. **Outlook**

Acknowledgements

- CoCo 2024 tool authors

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- Fabian Mitterwallner

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- IWC 2024 chairs

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- Aaron Stump

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2. **History**
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5. Outlook

2012	TRS	CPF
ACP	✓	
CSI	✓	✓
Saigawa	✓	
CeTA		✓

2013	TRS	CPF
ACP	✓	
CSI	✓	✓
Saigawa	✓	
CeTA		✓

2014	TRS	CPF	CTRS
ACP	✓	✓	
CSI	✓	✓	
Saigawa	✓		
CeTA		✓	
CoLL	✓		
ConCon		✓	✓
CO3			✓

2015	TRS	CPF	CTRS	HRS	GCR	NRS
ACP	✓	✓				
CSI	✓	✓				
CeTA		✓				
CoLL-Saigawa	✓					
ConCon		✓	✓			
CO3			✓			
CoScart			✓			
ACPH				✓		
CSIˆho				✓		
AGCP					✓	
NoCo						✓

2016	TRS	CPF-TRS	CTRS	HRS	GCR	NRS	UN	CPF-CTRS
ACP	✓	✓						
CSI	✓	✓					✓	
CeTA		✓						✓
CoLL-Saigawa	✓							
ConCon			✓					✓
CO3			✓					
CoScart			✓					
ACPH				✓				
CSIˆho				✓				
AGCP					✓			
Nrbox						✓		
FORT					✓		✓	

2017	TRS	CPF-TRS	CTRS	HRS	GCR	NFP	UNR	CPF-CTRS	UNC
ACP	✓	✓							
CSI	✓	✓				✓	✓		✓
CeTA		✓						✓	
CoLL-Saigawa	✓								
ConCon			✓					✓	
CO3			✓						
ACPH				✓					
CSIˆho				✓					
AGCP					✓				
FORT					✓	✓	✓		✓
SOL				✓					

2018	TRS	CPF-TRS	CTRS	HRS	GCR	NFP	UNR	CPF-CTRS	UNC
ACP	✓	✓	✓						✓
CSI	✓	✓				✓	✓		✓
CeTA		✓						✓	
CoLL-Saigawa	✓								
ConCon			✓					✓	
CO3			✓						
CSIˆho				✓					
AGCP					✓				
FORT					✓	✓	✓		✓
SOL				✓					

2019	TRS	CPF-TRS	CTRS	HRS	GCR	NFP	UNR	CPF-CTRS	UNC	COM	INF	SRS
ACP	✓	✓	✓						✓	✓		✓
CSI	✓	✓				✓	✓		✓			✓
CoLL										✓		
CeTA		✓						✓				
CoLL-Saigawa	✓											✓
ConCon			✓					✓			✓	
CO3			✓								✓	
infChecker											✓	
maedmax											✓	
CSIˆho				✓								
AGCP					✓							
Moca											✓	
FORT					✓	✓	✓		✓	✓		
noko-leipzig												✓
nonreach											✓	

2020	TRS	CPF-TRS	CTRS	HRS	GCR	NFP	UNR	CPF-CTRS	UNC	COM	INF	SRS
ACP	✓	✓	✓						✓	✓		✓
CSI	✓	✓				✓	✓		✓			✓
CoLL										✓		
CeTA		✓						✓				
CoLL-Saigawa	✓											✓
ConCon			✓					✓			✓	
CO3			✓								✓	
infChecker											✓	
CSIˆho				✓								
AGCP					✓							
Moca											✓	
FORT-h					✓	✓	✓		✓	✓		
SOL				✓								
nonreach											✓	

2021	TRS	CPF-TRS	CTRS		GCR	NFP	UNR		UNC	COM	INF	SRS
ACP	✓	✓	✓						✓	✓		✓
CSI	✓	✓				✓	✓		✓			✓
CoLL										✓		
CeTA		✓										
CoLL-Saigawa	✓											✓
CO3			✓								✓	
infChecker											✓	
FORTify	✓				✓		✓		✓	✓		
CONFident	✓		✓									✓
AGCP					✓							
NaTT											✓	
FORT-h					✓	✓	✓		✓	✓		

2022	TRS	CPF-TRS	CTRS		GCR	NFP	UNR	CSR	UNC	COM	INF	SRS
ACP	✓	✓	✓						✓	✓		✓
CSI	✓	✓				✓	✓		✓			✓
CoLL										✓		
CeTA		✓										
Hakusan	✓											✓
Toma											✓	
CO3			✓								✓	
infChecker											✓	
FORTify		✓			✓	✓	✓		✓	✓		
CONFident	✓		✓					✓				✓
AGCP					✓							
NaTT											✓	
FORT-h		✓			✓	✓	✓		✓	✓		

2023	TRS		CTRS		GCR	NFP	UNR	CSR	UNC	COM	INF	SRS
ACP	✓		✓				✓		✓	✓		✓
CSI	✓					✓	✓		✓			✓
CoLL										✓		
CeTA	✓									✓	✓	✓
Hakusan	✓											✓
Toma											✓	
CO3			✓								✓	
infChecker											✓	
FORTify	✓				✓	✓	✓		✓	✓		
CONFident	✓		✓					✓				✓
AGCP					✓							
NaTT											✓	
FORT-h	✓				✓	✓	✓		✓	✓		
ConfCSR								✓				
nonreach											✓	

- CoCo is powered by StarExec 

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- exciting to watch

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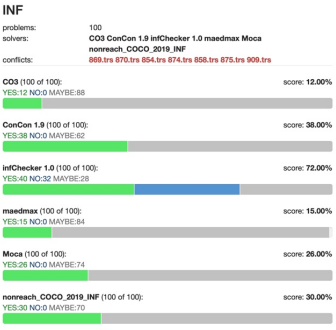
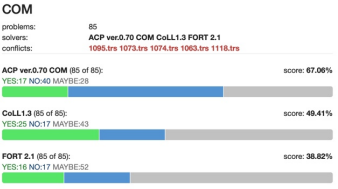
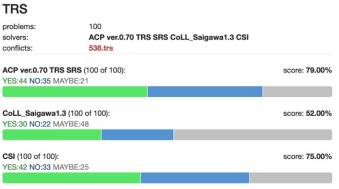
- exciting to watch, partly due to real-time yes / no conflicts







final slide CoCo 2023 presentation

- CoCo 2024 during IWC 2024 ?

final slide CoCo 2023 presentation

- CoCo 2024 during IWC 2024 ?
- new T-shirt ?

final slide CoCo 2023 presentation

- CoCo 2024 during IWC 2024 ?
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- new category on confluence of logically constrained rewrite systems LCTRS

final slide CoCo 2023 presentation

- CoCo 2024 during IWC 2024 ?
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- new category on confluence of logically constrained rewrite systems
- new format and infrastructure

LCTRS

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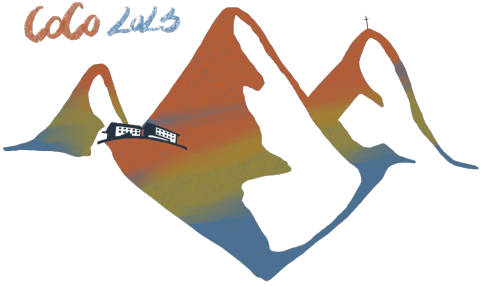
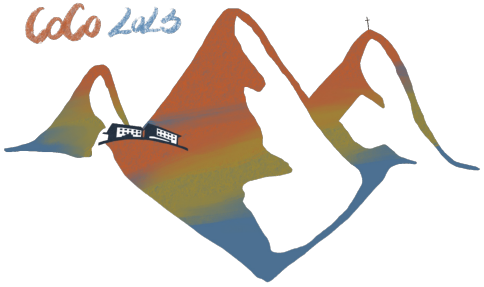


https://ari-cops.uibk.ac.at/liveview/2024.html



T shirt 20 €

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2023	TRS		CTRS		GCR	NFP	UNR	CSR	UNC	COM	INF	SRS
ACP	✓		✓				✓		✓	✓		✓
CSI	✓					✓	✓		✓			✓
CoLL										✓		
CeTA	✓									✓	✓	✓
Hakusan	✓											✓
Toma											✓	
CO3			✓								✓	
infChecker											✓	
FORTify	✓				✓	✓	✓		✓	✓		
CONFident	✓		✓					✓				✓
AGCP					✓							
NaTT											✓	
FORT-h	✓				✓	✓	✓		✓	✓		
ConfCSR								✓				
nonreach											✓	

2024	TRS	LCTRS	CTRS	GCR	NFP	UNR	CSR	UNC	COM	INF	SRS
ACP	✓		✓			✓		✓	✓		✓
CSI	✓				✓	✓		✓			✓
CeTA	✓								✓	✓	✓
Hakusan	✓										✓
Moca										✓	
CO3			✓							✓	
infChecker										✓	
FORTify	✓			✓	✓	✓		✓	✓		
CONFident	✓		✓				✓				✓
AGCP				✓							
NaTT										✓	
FORT-h	✓			✓	✓	✓		✓	✓		
CRaris		✓									
crest		✓									

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   Categories Rules Live View
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Categories

TRS	confluence of first-order term rewrite systems
CTRS	confluence of first-order conditional term rewrite systems
HRS	confluence of higher-order rewrite systems
GCR	ground-confluence of many-sorted first-order rewrite systems
LCTRS	confluence of logically constrained term rewrite systems
NFP	normal form property of first-order rewrite systems
UNR	unique normal forms wrt reduction of first-order rewrite systems
UNC	unique normal forms wrt conversion of first-order rewrite systems
COM	commutation of first-order rewrite systems
INF	infeasibility
SRS	confluence of string rewrite systems
CSR	confluence of context-sensitive rewriting

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Competition Rules

- Scoring
  - 100 random problems per category, using seed digits provided by panel members
  - tools output YES, NO or MAYBE on first line followed by proof
  - separate rankings for YES and NO and combined YES / NO answers
  - winning tools of 2023 participate as demonstration tools in 2024

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- Secret Problems
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  - at most two problems per category per tool

Secret Problems

0 secret problems submitted to CoCo 2023

Secret Problems

8 secret problems submitted to CoCo 2024:

- 2 by Takahito Aoto UNR 1606 1607

$$\mathsf{h}(\mathsf{f}(x),\mathsf{b}) \to \mathsf{c} \qquad \mathsf{b} \to \mathsf{a} \qquad \mathsf{c} \to \mathsf{f}(\mathsf{c})$$

$$\mathsf{a} \to \mathsf{b} \qquad \mathsf{f}(\mathsf{g}(\mathsf{b}),\mathsf{b}) \to \mathsf{f}(\mathsf{g}(\mathsf{a}),\mathsf{a}) \qquad \mathsf{f}(\mathsf{g}(x),\mathsf{a}) \to \mathsf{f}(\mathsf{g}(\mathsf{a}),\mathsf{a})$$

- 2 by René Thiemann INF 1612 1613

$$\mathsf{ack}(\mathsf{O},n) \to \mathsf{s}(n) \qquad \mathsf{isNat}(\mathsf{O}) \to \mathsf{true} \qquad \mathsf{isNat}(\mathsf{true}) \to \mathsf{false}$$

$$\mathsf{ack}(\mathsf{s}(m),\mathsf{O}) \to \mathsf{ack}(m,\mathsf{s}(\mathsf{O})) \qquad \mathsf{isNat}(\mathsf{s}(m)) \to \mathsf{isNat}(m) \qquad \mathsf{isNat}(\mathsf{false}) \to \mathsf{false}$$

$$\mathsf{ack}(\mathsf{s}(m),\mathsf{s}(n)) \to \mathsf{ack}(m,\mathsf{ack}(\mathsf{s}(m),n)) \qquad \mathsf{seven} \to \mathsf{s}(\mathsf{s}(\mathsf{s}(\mathsf{s}(\mathsf{s}(\mathsf{s}(\mathsf{s}(\mathsf{O})))))))$$

$$\mathsf{isNat}(\mathsf{ack}(\mathsf{seven},\mathsf{seven})) \overset{?}{\approx} \mathsf{true}$$

- 2 by Naoki Nishida LCTRS 1610 1611
- 2 by Jonas Schöpf LCTRS 1608 1609

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Problem Selection

Example: ARI−COPS queries for UNR category

1. `1606 or 1607`

2. `limit:98,361 1..1605 trs !CR:YES`

Problem Selection

Example: ARI–COPS queries for UNR category

1. `1606 or 1607`
   returns 2 secret problems
2. `limit:98,361 1..1605 trs !CR:YES`

- secret problems have numbers 1606 ... 1613

Problem Selection

Example: ARI–COPS queries for UNR category

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- 1605 problems in ARI–COPS database

Problem Selection

Example: ARI–COPS queries for UNR category

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- 1605 problems in ARI–COPS database
- exclude TRSs that are guaranteed to be confluent

Problem Selection

Example: ARI–COPS queries for UNR category

1. `1606 or 1607`
   returns 2 secret problems
2. `limit:98,361 1..1605 trs !CR:YES`
   returns 98 problems which are non-confluent

- secret problems have numbers 1606 ... 1613
- seed digits of panel members
- 1605 problems in ARI–COPS database
- exclude TRSs that are guaranteed to be confluent

Competition Rules

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- Incorrect Results
  - tools with incorrect results (observed during live competition due to YES / NO conflict, or communicated afterwards by tool authors to SC) are excluded from results table

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  - guaranteed to be selected
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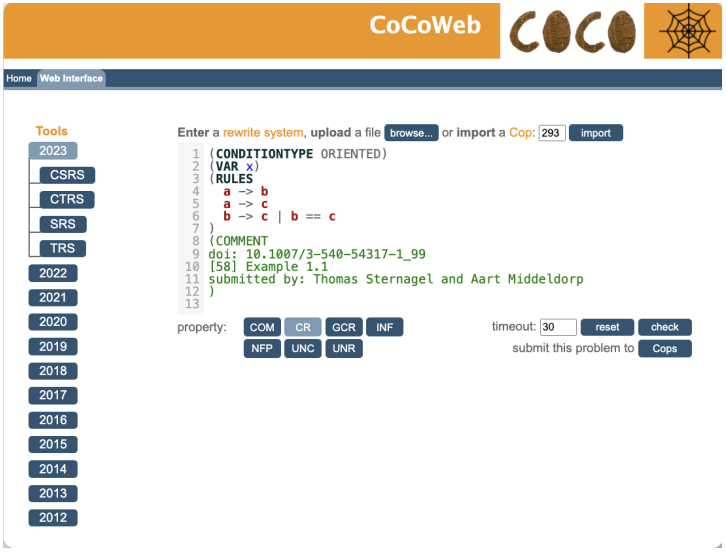
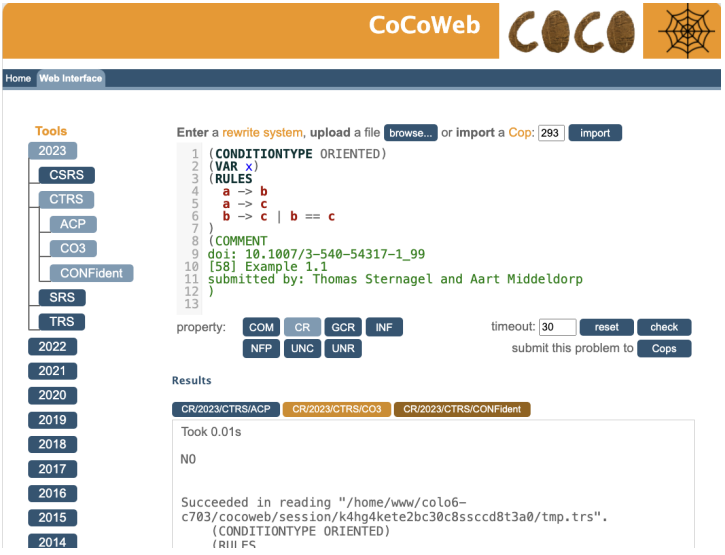
- Incorrect Results
  - tools with incorrect results (observed during live competition due to YES / NO conflict, or communicated afterwards by tool authors to SC) are excluded from results table
  - (corrected) tools are available from CoCoWeb for testing


CoCoWeb
Home
Web Interface
Tools
2023
CSRS
CTRS
SRS
TRS
2022
2021
2020
2019
2018
2017
2016
2015
2014
2013
2012
Enter a rewrite system, upload a file browse... or import a Cop: 293 import
1 (CONDITIONTYPE ORIENTED)
2 (VAR x)
3 (RULES
4 a -> b
5 a -> c
6 b -> c | b == c
7)
8 (COMMENT
9 doi: 10.1007/3-540-54317-1_99
10 [58] Example 1.1
11 submitted by: Thomas Sternagel and Aart Middeldorp
12)
13
property: COM CR GCR INF
NFP UNC UNR
timeout: 30 reset check
submit this problem to Cops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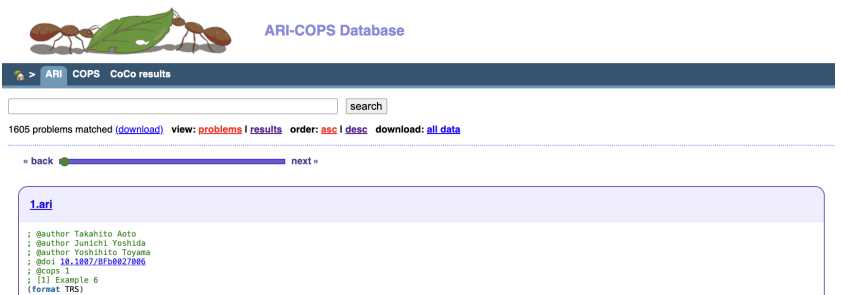
property: COM CR GCR INF
NFP UNC UNR
timeout: 30 reset check
submit this problem to Cops
Results
CR/2023/CTRS/ACP CR/2023/CTRS/CO3 CR/2023/CTRS/CONFident
Took 0.01s
NO
Succeeded in reading "/home/www/colo6-c703/cocoweb/session/k4hg4kete2bc30c8ssccd8t3a0/tmp.trs".
(CONDITIONTYPE ORIENTED)
(RULES



confluence problems database (ARI−COPS) consists of 1605 problems

CoCo 2024 Live View

https://ari-cops.uibk.ac.at/liveview/2024.html

2023 Results

TRS category

2023 Results

- previous winners: ACP 2012 2013 2014 2015 2019
  CSI 2015 2016 2017 2018 2020 2021 2022

2023 Results

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- 2024 participants: ACP ACP + CeTA CONFident CSI CSI + CeTA FORT-h
  FORT-h + FORTify Hakusan Hakusan + CeTA

2023 Results

TRS category

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UNIVERSITAT POLITÈCNICA DE VALÈNCIA

VRAIN Valencian Research Institute for Artificial Intelligence

CONFident **at CoCo 2024**

Miguel Vítores[1] Raúl Gutiérrez[1] Salvador Lucas[1]

TALLINN, JULY 9TH, 2024

[1] Valencian Research Institute for Artificial Intelligence
Universitat Politècnica de València
Spain

UPV

Description

- CONFident is a tool for checking **(non-)confluence** of Generalized Term Rewriting Systems (GTRSs).
- A GTRS is a tuple $\mathcal{R} = (\Omega, \mu, H, R)$, where:
  - $\Omega = (\mathcal{F}, \Pi)$ is a signature with predicates.
  - $\mu \in M_{\mathcal{F}}$.
  - H is a set of auxiliary clauses (H is used to model the semantics of conditions).
  - R is a set of rewrite rules $\ell \to r \Leftarrow c$.
- This year, our participation involves utilizing the same tool employed in the previous year.
- In the bibliography, you can find new publications on some techniques that were unpublished last year.

An Example

- Consider the GTRS $\mathcal{R}$:

$$x \geq 0 \qquad odd(x) \Leftrightarrow x \to^* s(0)$$
$$s(x) \geq s(y) \Leftrightarrow x \geq y \qquad zero(x) \Leftrightarrow x \to^* 0$$
$$peven(x) \Leftrightarrow x \to^* s(s(0)) \qquad s(s(x)) \to x \Leftrightarrow x \geq s(0)$$

- CONFident can prove the confluence of $\mathcal{R}$... details in Salvador Lucas's talk!

UPV

Implementation and Bibliography

- It is written in Haskell and implements the **Confluence Framework**. The tool is available here:

  `http://zenon.dsic.upv.es/confident/`

- Bibliography:

GL24 R. Gutiérez and S. Lucas. Proving Confluence in the Confluence Framework with CONFident. Fundamenta Informaticae 193, to appear, 2024.

GLV23 R. Gutiérez, S. Lucas and M. Vítores. Proving Confluence in the Confluence Framework with CONFident. CoRR abs/2306.16330, 2023.

Luc24 S. Lucas. Orthogonality of Generalized Term Rewriting Systems. Proc. of IWC'2024, to appear, 2024.

LVG22 S. Lucas, M. Vítores and R. Gutiérez. Proving and disproving confluence of context-sensitive rewriting. J. Log. Algebraic Methods Program. 126: 100749, 2022.

UPV

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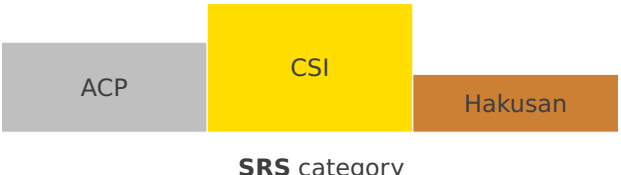

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- noko-leipzig produced most NO answers in 2019

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confluence tool for left-linear TRSs

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1. CeTA-certifiable proofs — joint work with Kim & Thiemann (CPP 2024)

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2. rule removal by rule labeling & critical pair systems — (LMCS & IWC 2024)

Hakusan v0.11 (Kawano, Hirokawa, Shintani, JAIST)

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Theorem (critical pair system)

$\mathsf{CR}(\mathcal{R}) \Leftrightarrow \mathsf{CR}(\mathcal{S})$ if $\mathcal{R}$ is LL, $\mathcal{S} \subseteq \mathcal{R}$, $\mathsf{PCP}(\mathcal{R}) \subseteq \downarrow_{\mathcal{R}}$, $\mathsf{SN}(\mathcal{P}/\mathcal{R})$, and $\mathcal{R}\restriction_{\mathcal{S}} \subseteq \to_{\mathcal{S}}^*$

- $\mathcal{P} = \left\{ \begin{matrix} s \to t \\ s \to u \end{matrix} \;\middle|\; t \mathrel{{}_{\mathcal{R}}\!\!\leftarrow\!\!\!+} s \xrightarrow[\mathcal{R}]{\epsilon} u \text{ is parallel critical peak but not } t \overset{*}{\underset{\mathcal{S}}{\longleftrightarrow}} u \right\}$
- $\mathcal{R}\restriction_{\mathcal{S}} = \{\ell \to r \in \mathcal{R} \mid \mathcal{F}\mathsf{un}(\ell) \subseteq \mathcal{F}\mathsf{un}(\mathcal{S})\}$

Confluence Proof by Rule Removal

consider left-linear TRS $\mathcal{R}$:

$$\mathsf{s}(\mathsf{p}(x)) \xrightarrow{\mathbf{1}} \mathsf{p}(\mathsf{s}(x)) \qquad \mathsf{p}(\mathsf{s}(x)) \xrightarrow{\mathbf{2}} x \qquad \infty \xrightarrow{\mathbf{3}} \mathsf{s}(\infty)$$

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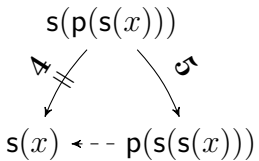

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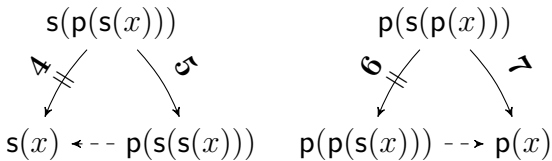

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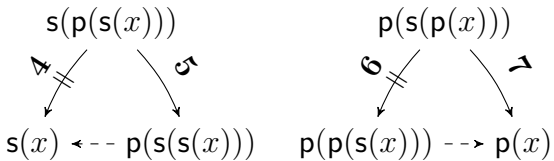

$\mathrm{SN}(\{\mathbf{4},\mathbf{5},\mathbf{6},\mathbf{7}\}/\mathcal{R})$

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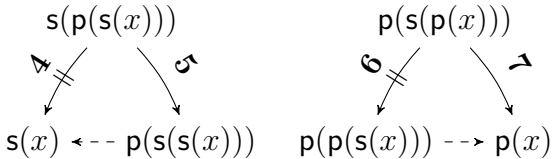

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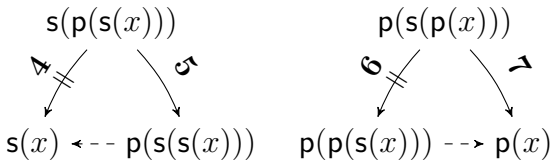

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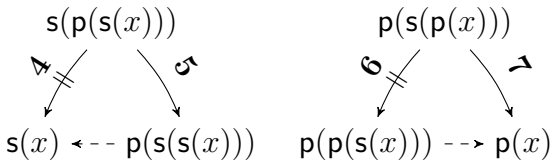

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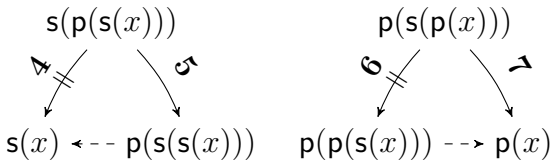

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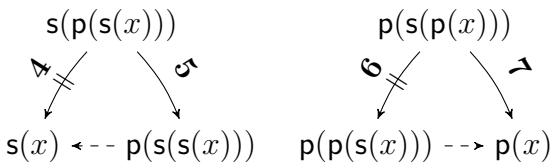

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2 $\mathsf{CR}(\{\mathbf{3}\}) \iff \mathsf{CR}(\varnothing)$ by rule labeling

3 $\mathsf{CR}(\varnothing)$ is trivial

2023 Results

INF category

2023 Results

INF category

- previous winner: infChecker 2019 2020 2021 2022

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VRAIN Valencian Research Institute for Artificial Intelligence

infChecker **at CoCo 2024**

Raúl Gutiérrez[1] Salvador Lucas[1]

TALLINN, JULY 9TH, 2024

[1] Valencian Research Institute for Artificial Intelligence
Universitat Politècnica de València
Spain

UPV

Description

- infChecker is a tool for checking **(in)feasibility of goals** $\mathcal{G} = \{F_i\}_{i=1}^{m}$, where $F_i = (s_{ij} \bowtie_{ij} t_{ij})_{i=1}^{n_i}$.
- $\bowtie_{ij}$ represents **predicates** on terms defined by provability of goals $s \bowtie_{ij} t$ with respect to a *first-order theories* $\mathrm{Th}_{\bowtie_{ij}}$.
- $\bowtie_{ij}$ can be one of the following predicates:
  - One (CS-)rewriting step (`->`, `\->`).
  - Zero or more (CS-)rewriting steps (`->*`, `\->*`).
  - One or more (CS-)rewriting steps (`->+`, `\->+`).
  - Subterm (`|>=`) and strict subterm (`|>`).
  - (CS-)Joinability (`->*<-`, `\->*<-/`).
  - One (CS-)convertibility step (`<->`, `<-/\->`).
  - Zero or more (CS-)convertibility steps (`<->*`, `<-/\->*`).
- This year, our participation involves utilizing the same tool employed in the previous year.

An Example

- Given the TRS $\mathcal{R} = \{a \to c(b), b \to c(b)\}$, infChecker can prove the nonloopingness of a as the infeasibility of

$$(\{\overline{\mathcal{R}}, Th_{\trianglerighteq}\}, \{\neg(x,y)(a \to x, x \to^* y, y \trianglerighteq a)\})$$

by obtaining the following structure over $\mathbb{N} \cup \{-1\}$:

$$\begin{array}{rr} a^{\mathcal{A}} = -1 & b^{\mathcal{A}} = 1 \\ c^{\mathcal{A}}(x) = x & x \to^{\mathcal{A}} y \Leftrightarrow x \leq 1 \wedge y \geq 1 \\ x\ (\to^*)^{\mathcal{A}}\ y \Leftrightarrow x \leq y & x \trianglerighteq^{\mathcal{A}} y \Leftrightarrow x \leq y \end{array}$$

Implementation and Bibliography

- It is written in Haskell and implements the **Feasibility Framework**. The tool is available here:

  `http://zenon.dsic.upv.es/infChecker/`

- Bibliography:

GL20 R. Gutiérez and S. Lucas. Automatically Proving and Disproving Feasibility Conditions. In Proc. of IJCAR'2020, LNCS 12167:416–435. Springer, 2020.

Luc19 S. Lucas. Proving semantic properties as first-order satisfiability. Artificial Intelligence 277, paper 103174, 24 pages, 2019.

LG18 S. Lucas and R. Gutiérrez. Use of Logical Models for Proving Infeasibility in Term Rewriting. Information Processing Letters, 136:90-95, 2018.

Moca 0.3

Yusuke Oi **Nao Hirokawa** **Teppei Saito**

JAIST

CoCo 2024

Maximal ordered completion with approximation

Would you like some coffee? Here it is!

Moca solves infeasibility problem $s \to^* t$ of CTRS $\mathcal{R}$ as follows:

Maximal ordered completion with approximation

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5. solve word problem by (maximal) ordered completion

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5. solve word problem by (maximal) ordered completion

news: Moca meets CeTA!

NaTT in CoCo 2024

Akihisa Yamada @ AIST

NaTT in CoCo

- NaTT a **termination prover** for **plain** term rewriting
- In CoCo 2021:
  - participated **INF** category with an easy checker [Sternagel & Yamada '19]
  - weak but fast
- In CoCo 2022:
  - **coWPO** for INF [IJCAR '22]
  - not too weak, but slow
- In CoCo 2024:
  - no time for research...
  - only adapted parser for ARI

2023 Results

CTRS category

2023 Results

CTRS category

- previous winners: CO3 2014 ConCon 2015 2016 2017 2018 2020 ACP 2019 CONFident 2021 2022

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CO3 (Ver. 2.5)

a **CO**nverter for proving **CO**nfluence of **CO**nditional TRSs

Naoki Nishida Misaki Kojima
Nagoya University, Japan

Overview

CO3 proves confluence of 3-DCTRSs or infeasibility of conditions by using

- very simple termination/confluence criteria for TRSs,
- the improved sequential unraveling $\mathbb{U}_{conf}$ [Gmeiner et al, 13],
- narrowing trees [Nishida & Maeda, 18], and
- reduction of confluence of join or semi-equational CTRSs to that of oriented ones

Infeasibility and Confluence Criterion

- Condition c is infeasible w.r.t. DCTRS $\mathcal{R}$ if $\mathbb{U}_{conf}(\mathcal{R})$ is right-linear and a narrowing tree for c defines $\emptyset$ [Maeda et al, 19]
- Syntactically deterministic 3-CTRSs $\mathcal{R}$ is confluent if either
  - $\mathcal{R}$ is weakly left-linear and $\mathbb{U}_{conf}(\mathcal{R})$ is confluent [Gmeiner et al, 13]
    or
  - $\mathbb{U}_{conf}(\mathcal{R})$ is terminating and right-linear
    and $\forall\langle s, t\rangle \Leftarrow c \in CP(\mathcal{R}),\ (c = \epsilon \wedge s = t) \vee$ "c is infeasible" [Maeda et al, 19]

- Added a new disproof criterion for confluence of $\mathcal{R}$ [Ver. 2.5]

2023 Results

GCR category

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GCR category

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AGCP (Automated Ground Confluence Prover)

Takahito Aoto

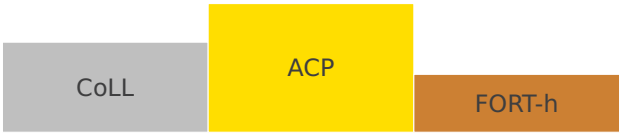
A ground confluence prover for many-sorted TRSs

- **An entrant of GCR category**
- **Written in Standard ML of New Jersey (SML/NJ)**
- **Methods:**
  - **rewriting induction for bounded convertibility**
  - **equivalent transformations, disproving methods**
- **Based on:**

  Improvements of the Rewriting Induction Approach for proving GCR, Aoto/Toyama/Kimura, FSCD 2017

We couldn't make any efforts on AGCP this year.

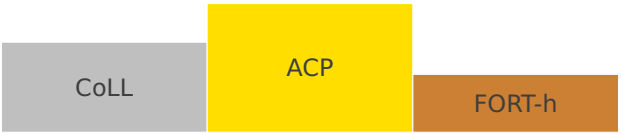
2023 Results



COM category

- CoLL had most YES answers

2023 Results



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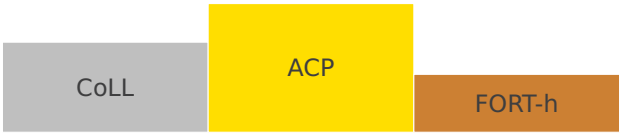

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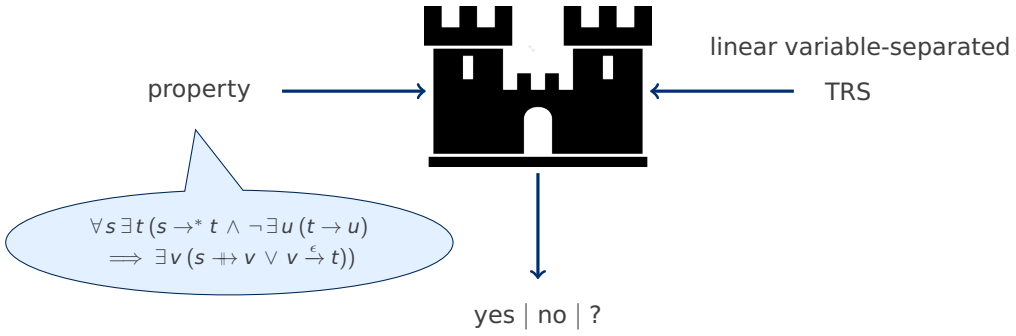
universität innsbruck

FORT-h 2.1

Fabian Mitterwallner Aart Middeldorp

University of Innsbruck

FORT-h



property is arbitrary formula in first-order theory of rewriting

- convenient web interface
- `https://fortissimo.uibk.ac.at/fort(ify)/`

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- FORT-h won RELIABILITY category in 2023

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CoCo 2024 Categories

COM GCR NFP TRS UNC UNR

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CoCo 2024 Categories

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CoCo 2024 Categories

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Literature

Aart Middeldorp, Alexander Lochmann and Fabian Mitterwallner

First-Order Theory of Rewriting for Linear Variable-Separated Rewrite Systems: Automation, Formalization, Certification

Journal of Automated Reasoning 67(2), 2023

doi: 10.1007/s10817-023-09661-7

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- FORT-h won RELIABILITY category in 2023
- FORT-h 2.1 accepts ARI format

CoCo 2024 Categories

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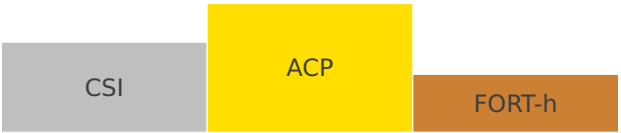
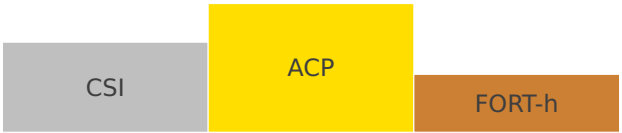


UNC category

2023 Results



UNC category

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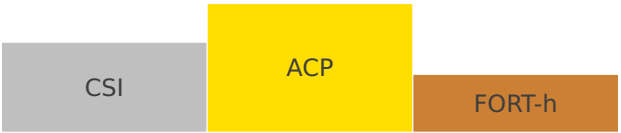
2023 Results



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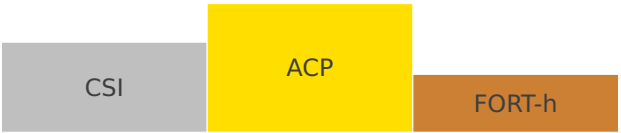

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ACP (Automated Confluence Prover)

Takahito Aoto

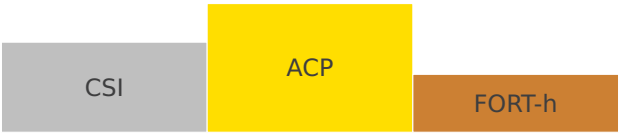
- ACP entered to COM/CTRS/SRS/TRS/UNR/UNC
- ACP+CeTA entered to COM/SRS/TRS
- Written in Standard ML of New Jersey (SML/NJ)
- Version: 0.10 (2009) ··· 0.74 (2024)
- Implementing multiple direct methods and divide-and-conquer methods
- New features:

  (i) UNR: (theoretically extended and) revised

  Proving Uniqueness of Normal Forms w.r.t. Reduction of Term Rewriting Systems, T. Aoto, LOPSTR 2024, to appear.

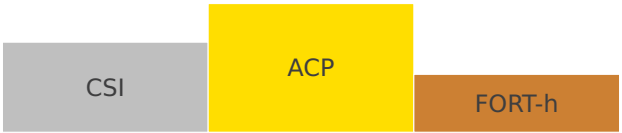
  (ii) COM: Certificates generation is extended and revised.

2023 Results



- FORT-h had most YES answers

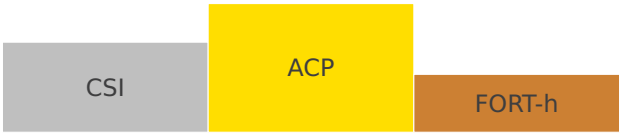
2023 Results



UNR category

- FORT-h had most YES answers
- previous winner: CSI 2017 2018 2019 2020 2021 2022

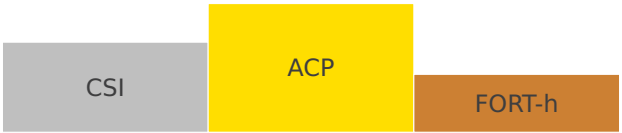
2023 Results



UNR category

- FORT-h had most YES answers
- previous winner: CSI 2017 2018 2019 2020 2021 2022
- 2024 participants: ACP CSI FORT-h FORT-h + FORTify

2023 Results



UNR category

- FORT-h had most YES answers
- previous winner: CSI 2017 2018 2019 2020 2021 2022
- 2024 participants: ACP CSI FORT-h FORT-h + FORTify

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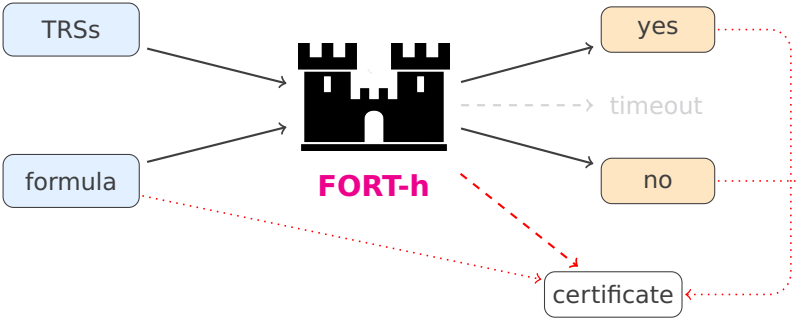
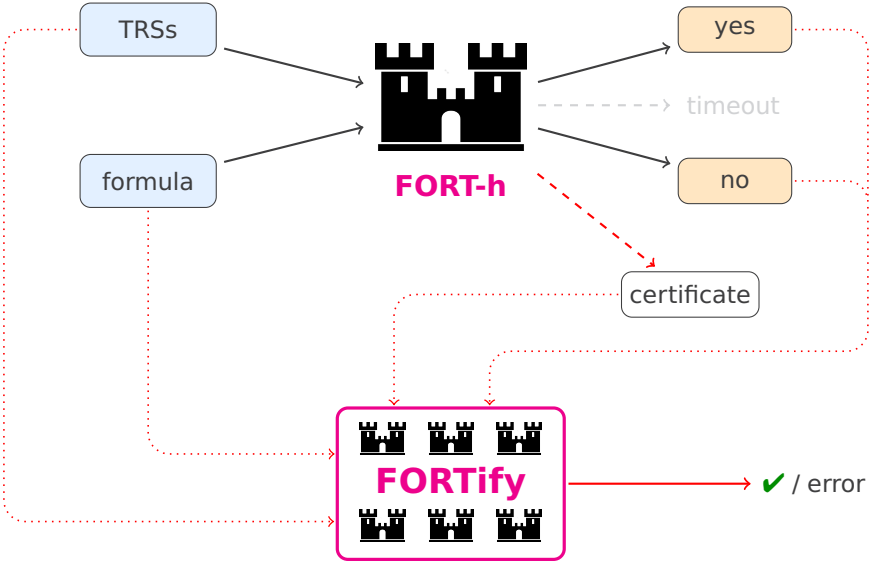
FORTify 2.1

Fabian Mitterwallner Aart Middeldorp

University of Innsbruck


TRSs
formula
FORT-h
yes
timeout
no
certificate


TRSs
formula
FORT-h
yes
timeout
no
certificate
FORTify
✔ / error

- code generated from formalization of decision procedure in Isabelle/HOL
- `https://fortissimo.uibk.ac.at/fort(ify)/`

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CoCo 2024 Categories

COM GCR NFP TRS UNC UNR (with FORT-h)

- code generated from formalization of decision procedure in Isabelle/HOL
- `https://fortissimo.uibk.ac.at/fort(ify)/`

CoCo 2024 Categories

COM GCR NFP TRS UNC UNR (with FORT-h)

Literature

Aart Middeldorp, Alexander Lochmann and Fabian Mitterwallner

First-Order Theory of Rewriting for Linear Variable-Separated Rewrite Systems: Automation, Formalization, Certification

Journal of Automated Reasoning 67(2), 2023

doi: 10.1007/s10817-023-09661-7

2023 Results

NFP category

2023 Results

- previous winner: CSI 2017 2018 2019 2020 2021 2022

2023 Results

- previous winner: CSI 2017 2018 2019 2020 2021 2022
- 2024 participants: CSI FORT-h FORT-h + FORTify

2023 Results

- previous winner: CSI 2017 2018 2019 2020 2021 2022
- 2024 participants: CSI FORT-h FORT-h + FORTify

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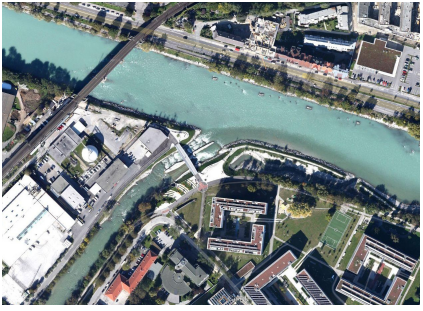
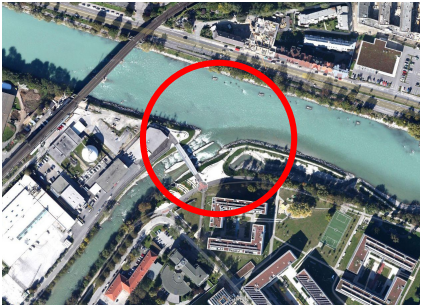
CSI 1.2.7

Fabian Mitterwallner Aart Middeldorp

University of Innsbruck

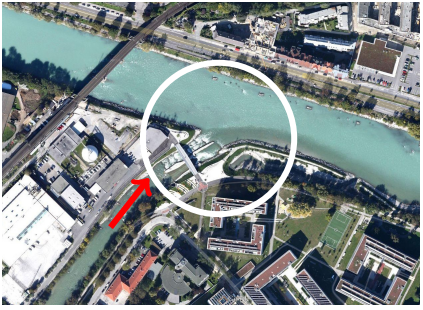


[Google Maps]



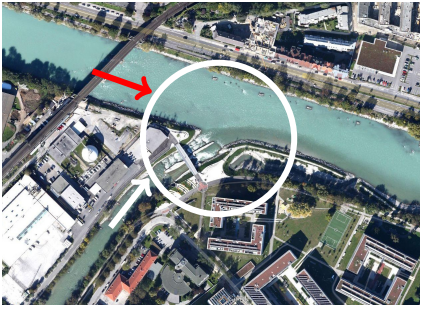
[Google Maps]

C



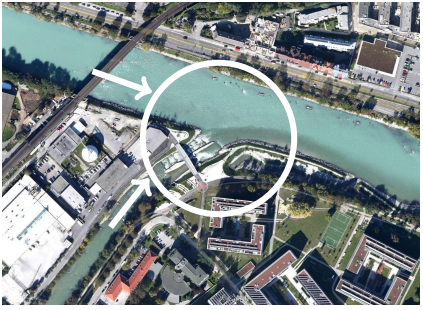
[Google Maps]

CS



[Google Maps]

CSI



[Google Maps]

CSI 1.2.7

- open source
- convenient web interface
- `http://cl-informatik.uibk.ac.at/software/csi/`

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CoCo 2024 Categories

- SRS TRS UNC UNR NFP
- SRS TRS with CeTA

- open source
- convenient web interface
- `http://cl-informatik.uibk.ac.at/software/csi/`

CoCo 2024 Categories

- SRS TRS UNC UNR NFP — 1st place in 2023
- SRS TRS with CeTA

- open source
- convenient web interface
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CoCo 2024 Categories

- SRS TRS UNC UNR NFP
- SRS TRS with CeTA

No New Features in 2024

- CSI uses ARI $\rightarrow$ COPS conversion tool

2023 Results

CSR category

2023 Results

CSR category

- previous winner: CONFident 2022

2023 Results

CSR category

- previous winner: CONFident 2022
- 2024 participants: CONFident

2023 Results

certification category

2023 Results

- 2024 participants: CeTA FORTify

2023 Results

- 2024 participants: CeTA FORTify

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JAIST
JAPAN
ADVANCED INSTITUTE OF
SCIENCE AND TECHNOLOGY
1990

CoCo 2024 Participant: CeTA 3.2

Dohan Kim,[1] Christina Kirk,[1] Teppei Saito[2] and René Thiemann[1]

1: University of Innsbruck, Austria
2: Japan Advanced Institute of Science and Technology, Japan

CeTA 3.2

- CeTA: certifier of various properties, verified in Isabelle/HOL
- mostly developed by Computational Logic Group in Innsbruck
- several confluence techniques supported, see a complete list at:

  `http://cl-informatik.uibk.ac.at/software/ceta/`

- usage in CoCo: certify proofs and disproofs of
  - confluence
  - commutation
  - infeasibility (new in 2024: feasibility)
- usage in ARI-database: certify YES/NO for CR/COM/INF-tags

New techniques in CeTA 3.2 in comparison to 2023

- several new term orders for non-CR/COM and infeasibility proofs
  - CoWPO and WPO (weighted path order)
  - generalized WPO and MSPO (monotonic semantic path order)
  - polynomial interpretations over $\mathbb{Z}_{\leqslant 0}$
- non-joinability proofs via finite sets of reachable terms
- feasibility proofs via explicit conditional rewrite sequences
  (no certificate generating tool yet)
- infeasibility proofs by unraveling and Knuth–Bendix completion
  (used by Moca)

New CPF 3 format in 2024

- converter from CPF 2 available (based on xsltproc)
- more consistent confluence proofs, e.g., same format for joining sequences
- better support for competitions, e.g., overwrite input and answer in CPF3
- more concise certificates
  - rule- and term-indexing
  - removed superfluous XML-elements

```
<polynomial><sum>
  <polynomial><variable>1</variable></polynomial>
  <polynomial><coefficient><integer>2</integer></coefficient></polynomial>
</sum></polynomial>
```

to specify $x_1 + 2$ in CPF 2 becomes the following in CPF 3:

```
<sum><variable>1</variable><integer>2</integer></sum>
```

2023 Results

reliability category

2023 Results

- 2024 participants: ACP CSI FORT-h Hakusan Moca

2023 Results

LCTRS category

2023 Results

LCTRS category

- new category supported by FWF–JSPS ARI project

2023 Results

LCTRS category

- new category supported by FWF–JSPS ARI project

- 2024 participants: CRaris crest

CRaris

a **CR** checker for LCTRSs in **ARI** style

Naoki Nishida Misaki Kojima
Nagoya University, Japan

Overview

CRaris, which is a part of Crisys2, proves confluence of LCTRSs written in ARI style

- Crisys2 is a rewriting-induction tool for LCTRSs

Supported SMT-LIB Theories

`Core`, `Ints`, `FixedSizeBitVecotrs`

Implemented Confluence Criteria

- weak orthogonality (left-linearity + triviality of CPs) [Kop and Nishida, 2013]
- termination + triviality of CPs [Schöpf and Middeldorp, 2023]

Implemented Termination Criteria

DP framework for LCTRSs [Kop, 2013] with

- SCC processor
- singleton self-looping removal processor for BV-LCTRSs [Matsumi et al, 2023]

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supported by FWF project I 5943-N

crest 0.8

Jonas Schöpf Aart Middeldorp

University of Innsbruck

- Constrained REwriting Software Tool

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- confluence and termination analysis of logically constrained rewrite systems

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- Constrained REwriting Software Tool
- confluence and termination analysis of logically constrained rewrite systems
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- crest uses Z3 as SMT solver

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- crest implements various confluence criteria based on critical pairs

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- crest implements simple non-confluence tests

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CoCo 2024 Categories

LCTRS

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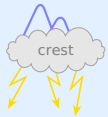


CoCo 2024 Categories

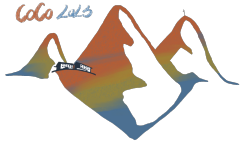
LCTRS

and the 2024 winners are . . .

https://ari-cops.uibk.ac.at/liveview/2024.html

Outline

1. Acknowledgements
2. History
3. 2024
4. **Awards**
5. Outlook



the steering committee of the

12th Confluence Competition

awarded

TOOL by *TOOL authors*

the

First Place in the ? category

Obergurgl, 23 August 2023

Awards

- top three tools in each category (excluding tool + certifier)

Awards

- top three tools in each category (excluding tool + certifier)
- certifiers based on total number of certified answers

CERTIFICATION

Awards

- top three tools in each category (excluding tool + certifier)
- certifiers based on total number of certified answers CERTIFICATION
- top three tools that produce most certifiable answers RELIABILITY

Awards

- top three tools in each category (excluding tool + certifier)
- certifiers based on total number of certified answers — CERTIFICATION
- top three tools that produce most certifiable answers — RELIABILITY

no Award Ceremony: certificates will be sent by email

Outline

1. Acknowledgements
2. History
3. 2024
4. Awards
5. **Outlook**

Outlook

- CoCo 2025 during IWC 2025 ?

Outlook

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- new T-shirt ?

Outlook

- CoCo 2025 during IWC 2025 ?
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  - HRS
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14th International School on Rewriting (ISR 2024)

August 25 — September 1

Obergurgl

http://cl-informatik.uibk.ac.at/isr24/