

Rewriting Games on Nested Words

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Context-Free Games On Strings: Intuition

Basic idea:

- Context-free grammar as two-player game
- JULIET chooses function symbols
- ROMEO chooses replacement strings
- JULIET wins if a target string is reached

Example

$$T = \{afba, aafafa, abafa\},$$
$$f \rightarrow af \mid b$$
$$af \color{blue}fa$$
$$\downarrow$$
$$af \color{blue}afa$$
$$\downarrow$$
$$abafa$$

Algorithmic problem JWIN

Given: A context-free game G and a string w

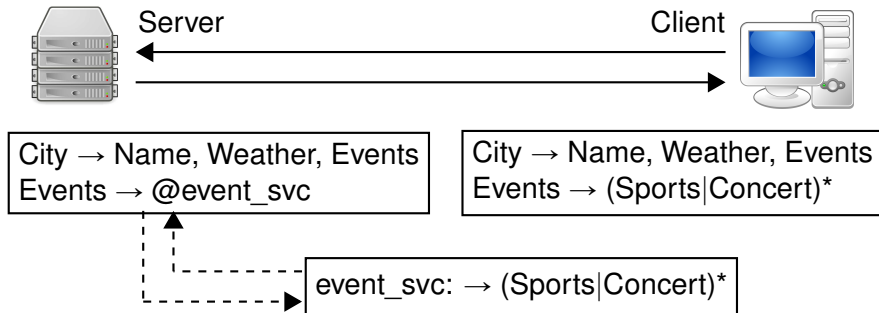
Question: Does JULIET have a winning strategy on w in G ?

Previous Results

(Some) results from [Muscholl, Schwentick, Segoufin 2006]:

- JWIN is undecidable in general
 - ↳ Left-to-right (L2R) restriction
- With L2R restriction and DFA-represented target language, JWin is
 - EXPTIME-complete for finite or (D/N)FA-represented regular replacement languages
 - PTIME-complete for finite replacement languages and bounded recursion

Application: Active XML Schema Rewriting



Server (CC-BY-SA 3.0) RRZE Icons, Client (LGPL) Everaldo Coelho

- Goal: Rewrite server documents into client schema
- Milo *et al.*, 2003: DTD schema languages
 - ~> Reduction to string rewriting
 - ~> Claimed PTIME algorithm for bounded recursion (?)
- Our interest: stronger schema languages (XML Schema)
 - ~> Main target: identify tractable restrictions
 - ~> cfGs on **nested words**

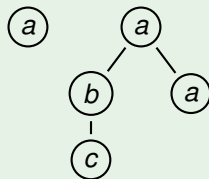
Nested Words

Idea: Correct nesting of tags over label alphabet Σ

~> Linearisations of Σ -labelled forests

Example

$\langle a \rangle \langle /a \rangle \langle a \rangle \langle b \rangle \langle c \rangle \langle /c \rangle \langle /b \rangle \langle a \rangle \langle /a \rangle \langle /a \rangle$



Schema specifications for nested words:

- ~> (Variant of) [nested word automata](#) (Alur, Madhusudan 2009)
- ~> [Regular languages](#) (of nested words)
- ~> Restriction for XML Schema: [Simple](#) NWA

Context-Free Games On Nested Words

Example

$$T = \{\langle f \rangle \langle /f \rangle \langle a \rangle^n \langle /a \rangle^n \mid n \geq 0\},$$

$$f \rightarrow \{\langle a \rangle^n \langle g \rangle^m \langle /g \rangle^m \langle /a \rangle^n \mid n, m \geq 0\},$$

$$g \rightarrow \{\langle a \rangle \langle /a \rangle\}$$

$$\langle f \rangle \langle /f \rangle \langle f \rangle \langle a \rangle \langle /a \rangle \langle /f \rangle$$



$$\langle f \rangle \langle /f \rangle \langle a \rangle \langle g \rangle \langle /g \rangle \langle /a \rangle$$



$$\langle f \rangle \langle /f \rangle \langle a \rangle \langle a \rangle \langle /a \rangle \langle /a \rangle$$

Difference to games on “flat” strings:

- General L2R restriction
- Function calls delete subtrees
(Original intention: function parameters)

(Some of) Our Results

- Complexity for JWin with arbitrary regular target language:

	No recursion	Bounded	Unbounded
Regular replacement	PSPACE	2-EXPTIME	2-EXPTIME
Finite replacement	PSPACE	PSPACE	EXPTIME

→ Data complexity: PSPACE




- DTD or XML Schema target language:

	No recursion	Bounded	Unbounded
Regular replacement	PTIME	PSPACE	EXPTIME
Finite replacement	PTIME	PTIME	EXPTIME

→ Data complexity: PTIME

All results are completeness results.

Literature I

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