CSPSAT Projects and My Research Topics

Takehide Soh

March 18, 2014 at NII

Self Introduction

Takehide SOH

1. 2008.04-2011.11
   SOKENDAI, Ph.D., in Inoue Lab.
   Studied applications of SAT technologies (solving 2SPP and pathway analyses)
2. 2011.11-2012.03
   TRIC, Post-doc., in Inoue Lab.
   Continuously studied pathway analyses
3. 2012.04-Current
   Kobe Univ., Assist. Prof., in Tamura Lab.
   Studying SAT-based CP System written in Scala (Scarab) and its applications.

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CSPSAT and CSPSAT2 Projects

Overview

- CSPSAT project started on 2008 and is followed by running CSPSAT2 project started on 2012.
- The goal of projects is the research and development of enhanced SAT technologies as high-performance inference engines for hard problems.

Developed Software

SAT-based CSP Solvers Sugar, Azucar

Max-SAT and PB Solvers QMaxSat, PBSugar

SAT Solvers GlueMiniSat, SCSat

Domain Specific Languages for CP Scarab, Copris and more...

Introduce members and some researches in CSPSAT projects.

Members of CSPSAT

Kobe
– Naoyuki Tamura
– Katsutoshi Hirayama
– Mutsunori Banbara

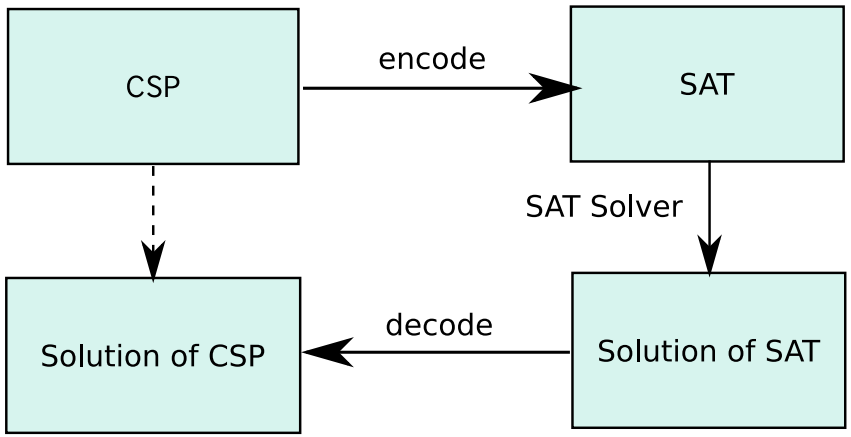
Yamanashi
– Koji Iwanuma
– Hidetomo Nabeshima
– Yoshitaka Yamamoto

Kyushu
– Ryuzo Hasegawa
– Makoto Yokoo
– Hiroshi Fujita
– Miyuki Koshimura

NII
– Katsumi Inoue

Waseda
– Kazunori Ueda

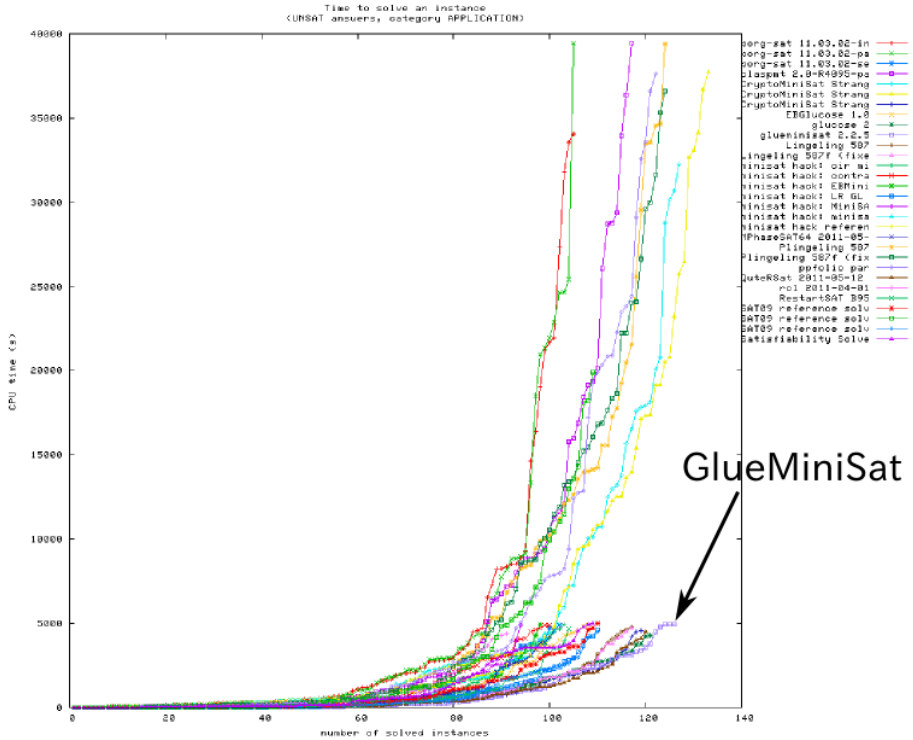
Sugar (Tamura et al.)
SAT-based CSP Solver



- Based on a new encoding named Order Encoding [Tamura et al., Constraints 2009]
- Winner of 2008 and 2009 CSP Solver Competitions in GLOBAL categories
- Closed three instances (j7-per0-0, j8-per0-1, j8-per10-2) of Open-Shop Scheduling Problem [Tamura et al., CP2006]
- There is also another version Azucar using Compact Order Encoding [Tanjo et al., SAT 2012].

GlueMiniSat (Nabeshima et al.)

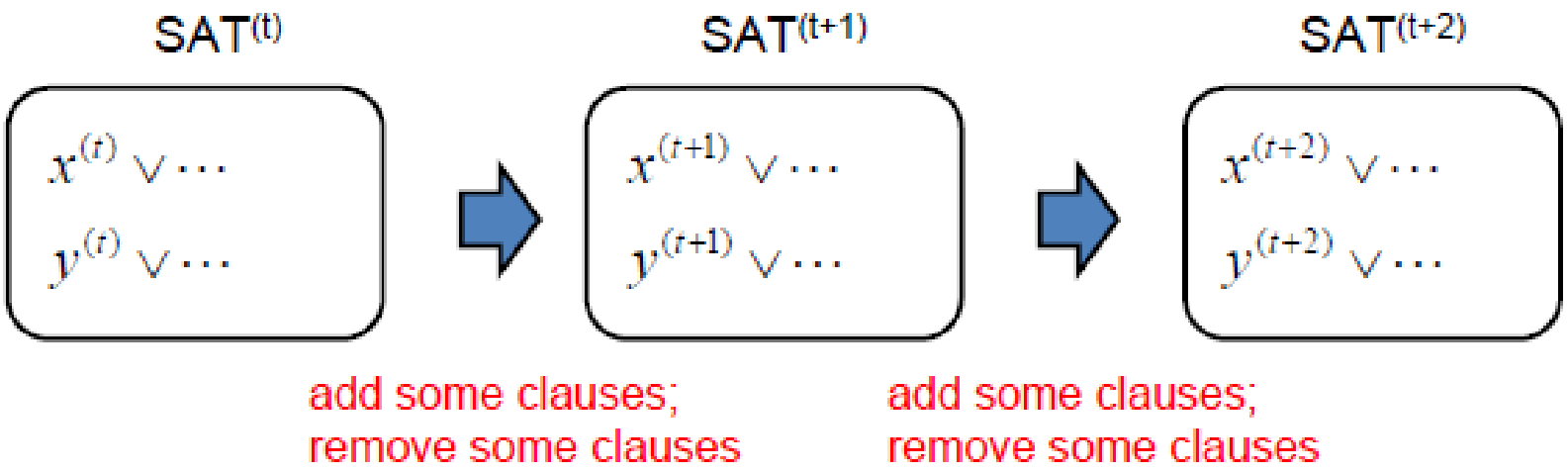
A Fast SAT Solver with An Aggressive Acquiring Strategy of Glue Clause



- Won several prizes of SAT competitions of 2011 and 2013 in Application, UNSAT category.
- Strong for UNSAT

Dynamic CSP/SAT (Hatano, Hirayama et al.)

Solving a Sequence of CSP/SAT Instances with Decision Change Costs



- Find a sequence of solutions that minimizes the sum of decision change costs for a given sequence of CSP/SAT instances.
- Lagrangian Decomposition works very well in terms of solution quality reached within a fixed amount of time [Hatano and Hirayama, IJCAI 2011].

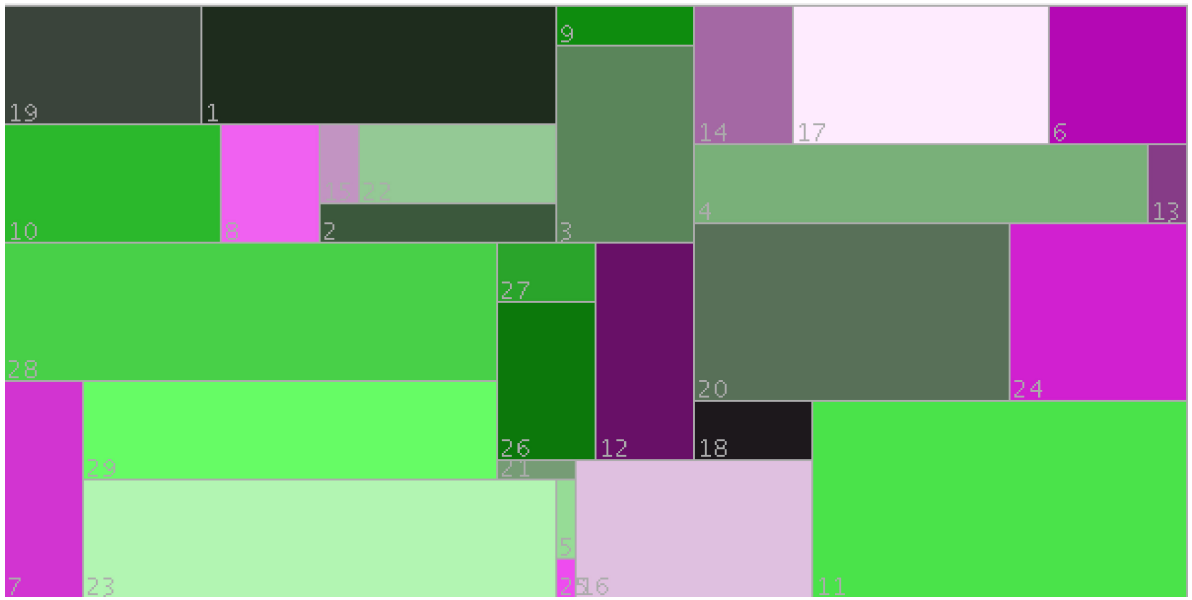
ASP as a Modeling Language for CB-CTT (Banbara et al.)

Proposed ASP-based method provides **175 best known bounds**.

Methods	Authors	# of Bests
ASP-based	M. Banbara	175
Tabu Search (110) Hybrid Methods (1)	A. Schaerf	111
Other	S. Abdullah & H. Turabieh	30
Tabu Search	Z. Lu & J. Hao	24
SAT-based	Barcelogic Team	19
Mathematical Programming	A. Phillips	18
Mathematical Programming	G. Lach	5
Local Search	T. Muller	5
Simulated Annealing	SaTT group	3
Very Large Neighborhood Search	A. Kiefer	2
Simulated Annealing	M. Muehlenthaler	1
Hybrid Methods	Khalid & Salwan	1

My Research Topics on CSPSAT

Two-Dimensional Strip Packing (Soh and Inoue et al.)

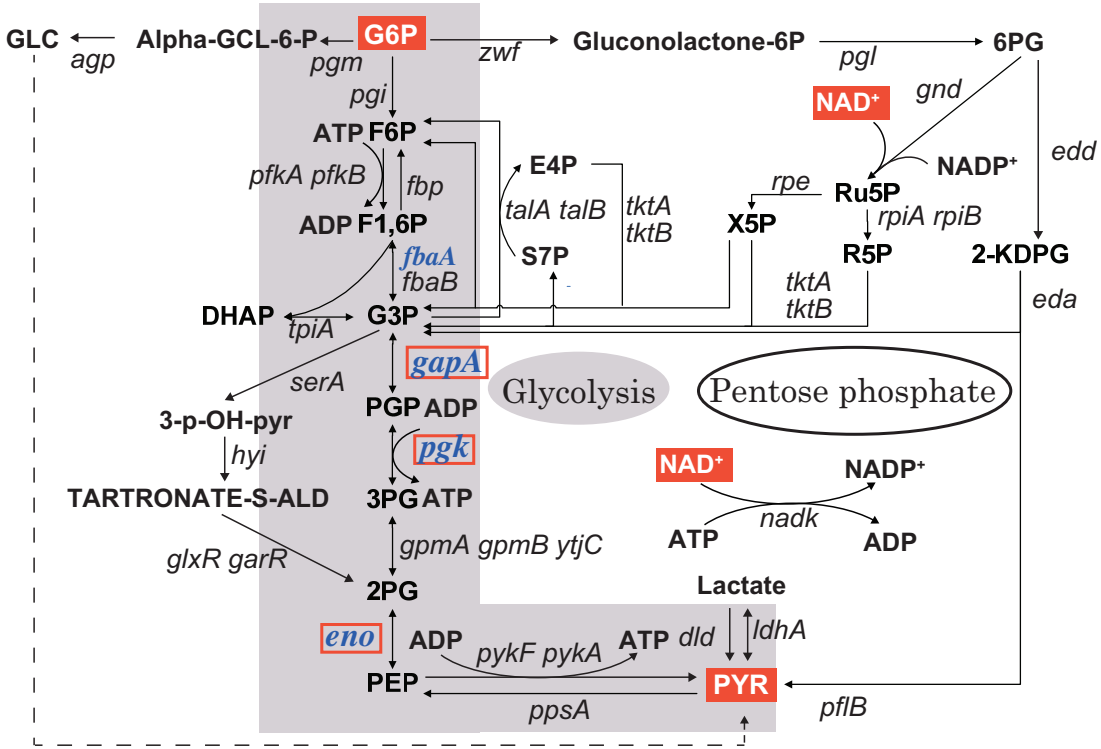


Optimum Packing of HT08

- Find a minimum height to pack all given rectangles in a fixed width strip.
- Closed 29 instances [Soh et al., FI, 2010]

My Research Topics on CSPSAT

Prediction of Gene Knockout Effects by Minimal Model Generation



Source metabolites (M_S): β-D-glucose-6-phosphate, NAD+	G6P NAD+
Target metabolite (M_T): pyruvate	PYR
Four essential genes confirmed by KEIO collection	*fbaA* *gapA* *pgk* *eno*
Genes predicted by our method	

Essential Genes of E. coli Predicted by a SAT-based Analysis Method [Soh and Inoue et al., Intl. J. Advances in Life Sciences, 2012]

My Research Topics on CSPSAT2: Motivation

Researches I studied until 2012

- Solving Two-Dimensional Strip Packing Problem
  - Proposing a new solving method for an existing problem
- Analyses for Metabolic Pathways
  - Focusing on a Biological problem (Gene knockout effects)
  - Represent it as a new problem on bipartite digraphs
  - Proposing a solving method
- Both researches use SAT technologies and need trial and error on propositional modeling.

There are general demands of an useful workbench on SAT.

This is the motivation for the development of **Scarab**.

My Research Topics on CSPSAT2: Scarab

Tight Integrated System with SAT Solvers

- **Scarab** is a prototyping tool for developing SAT-based Constraint Programming (CP) systems.

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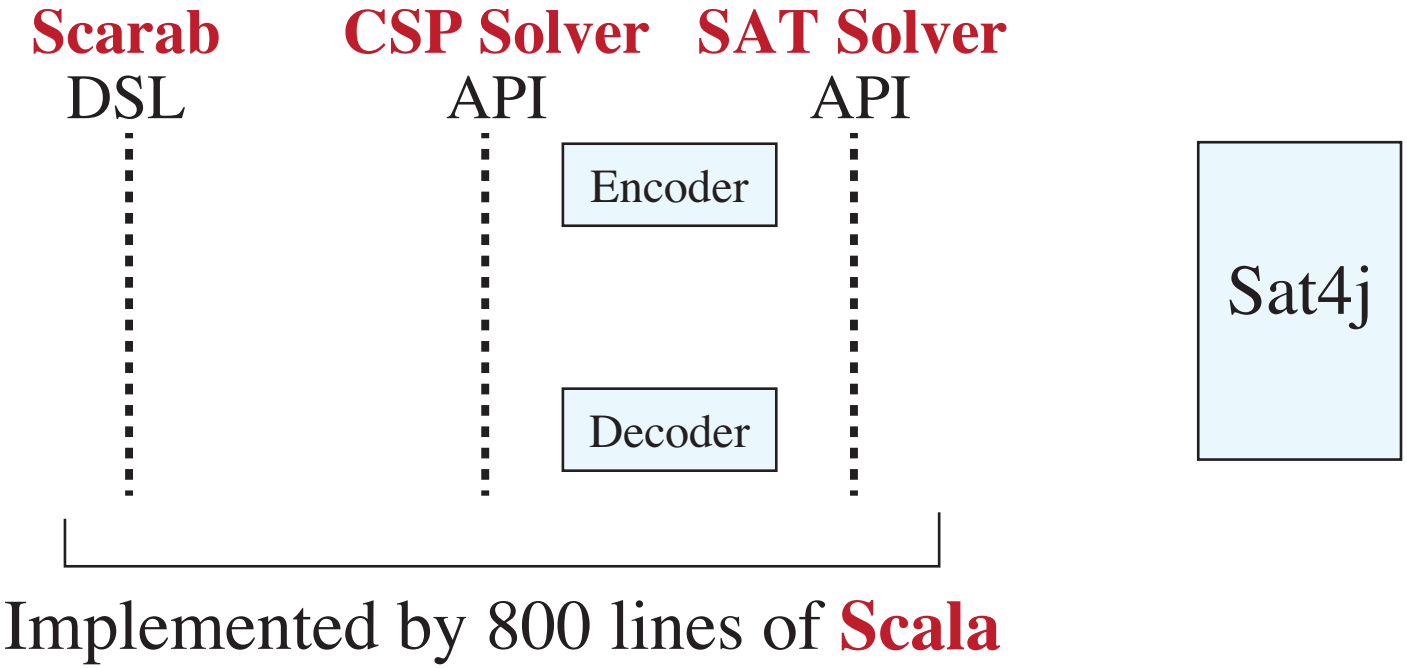

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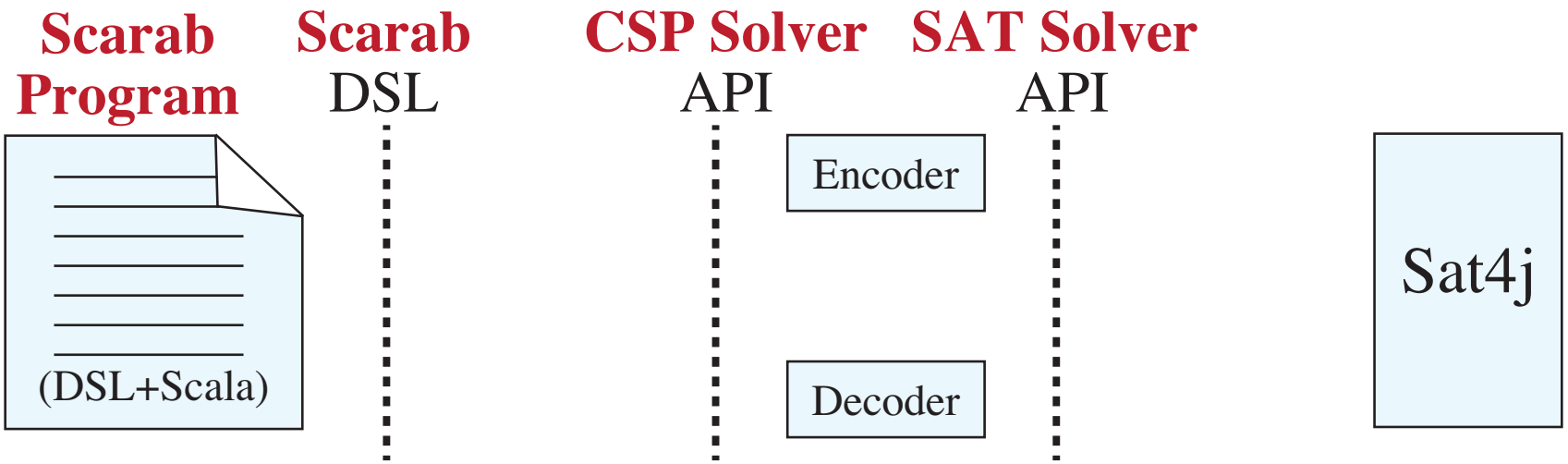

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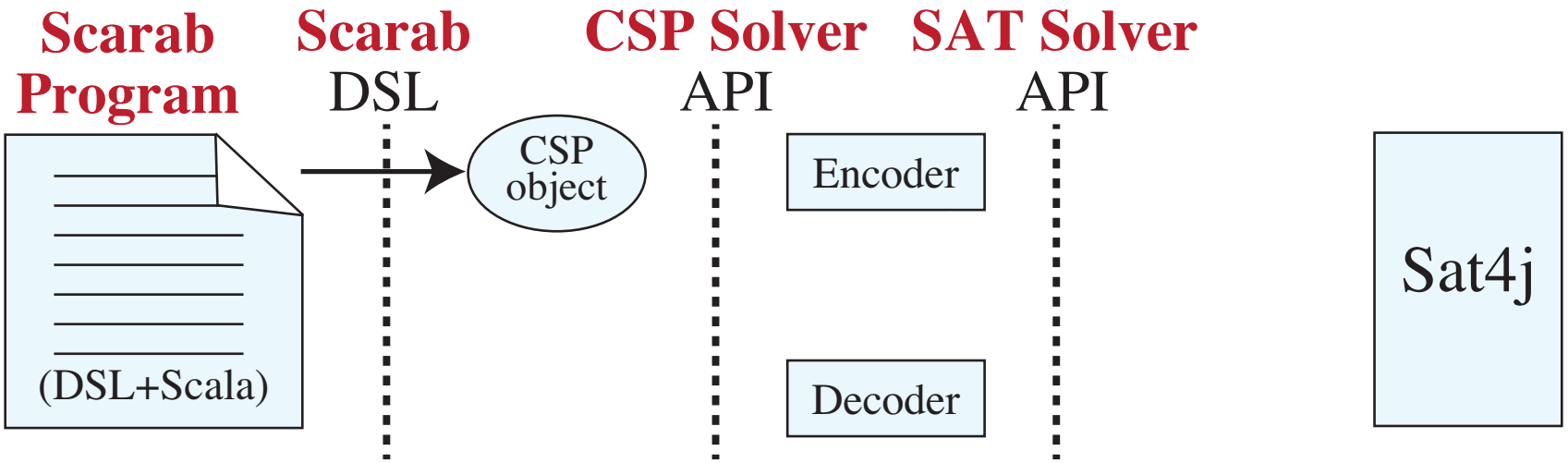

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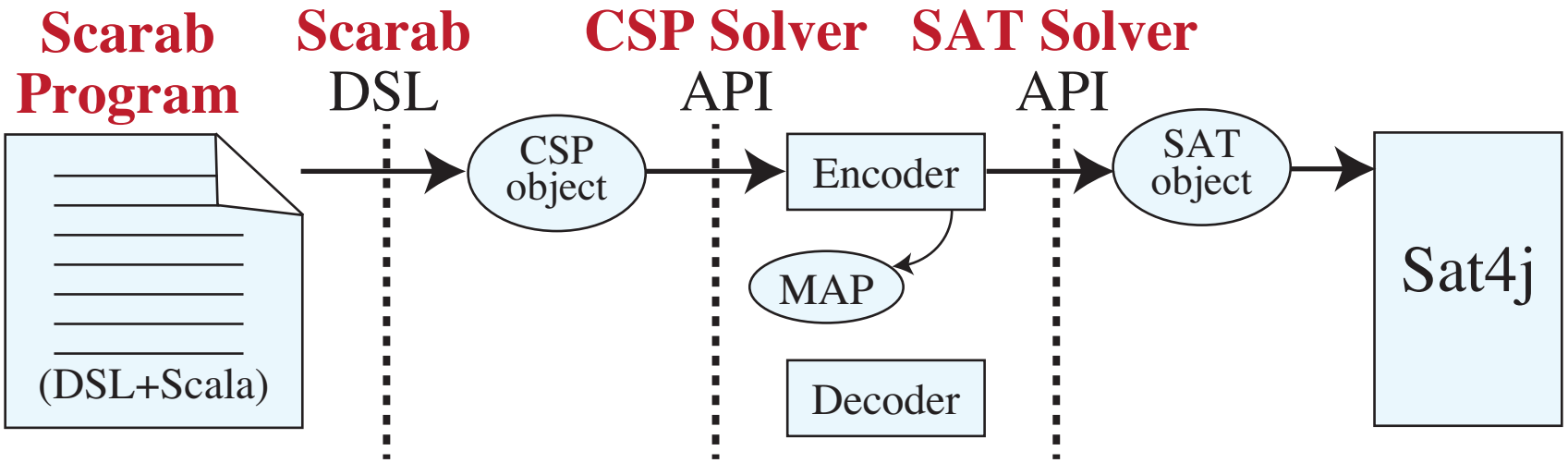

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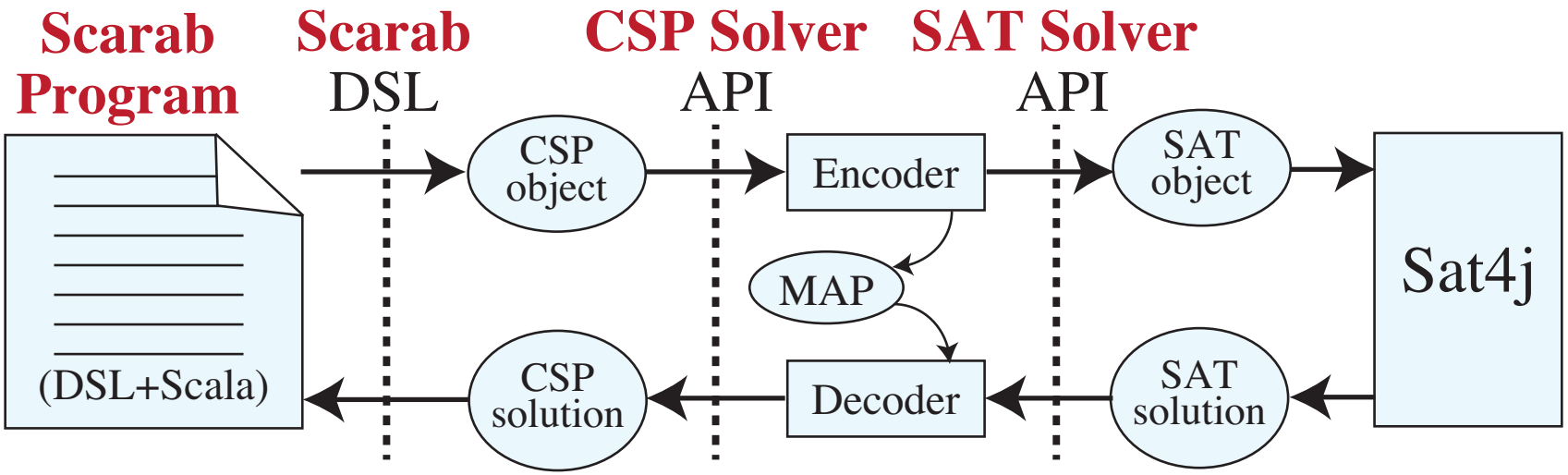

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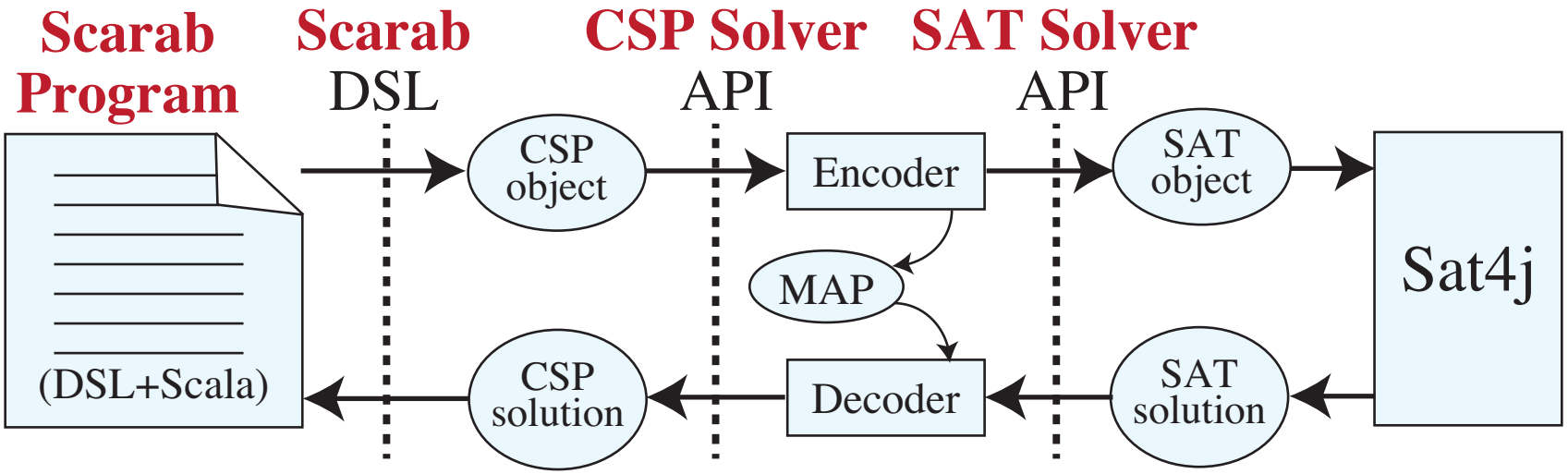
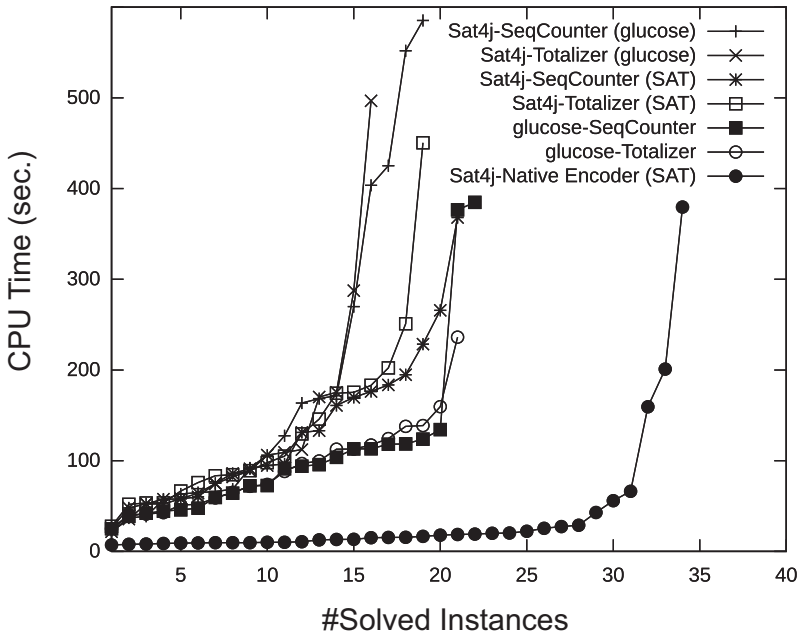


- It is developed to be an expressive, efficient, customizable, and portable workbench.

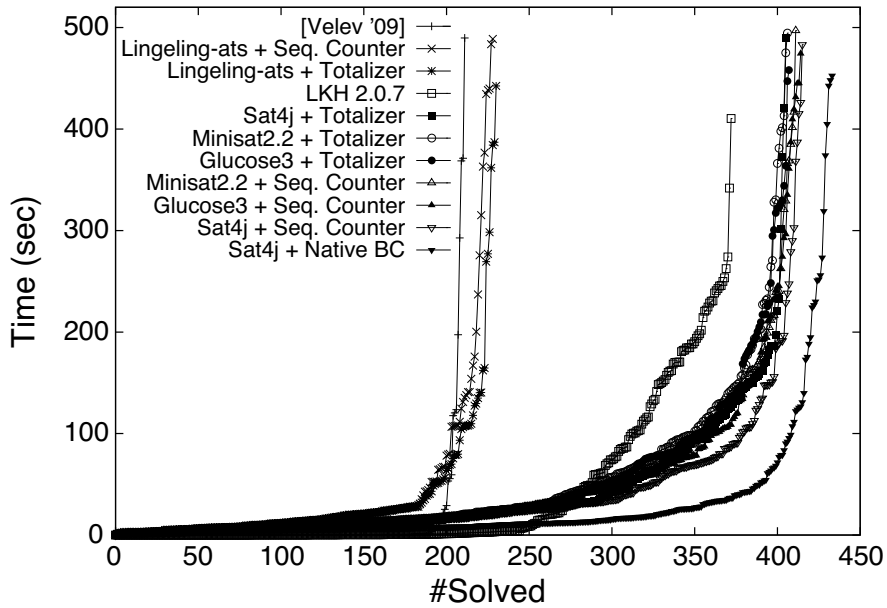
My Research Topics on CSPSAT2: Scarab

Applications using Scarab

We are now developing several applications using Scarab and they show good performances compared to other systems.



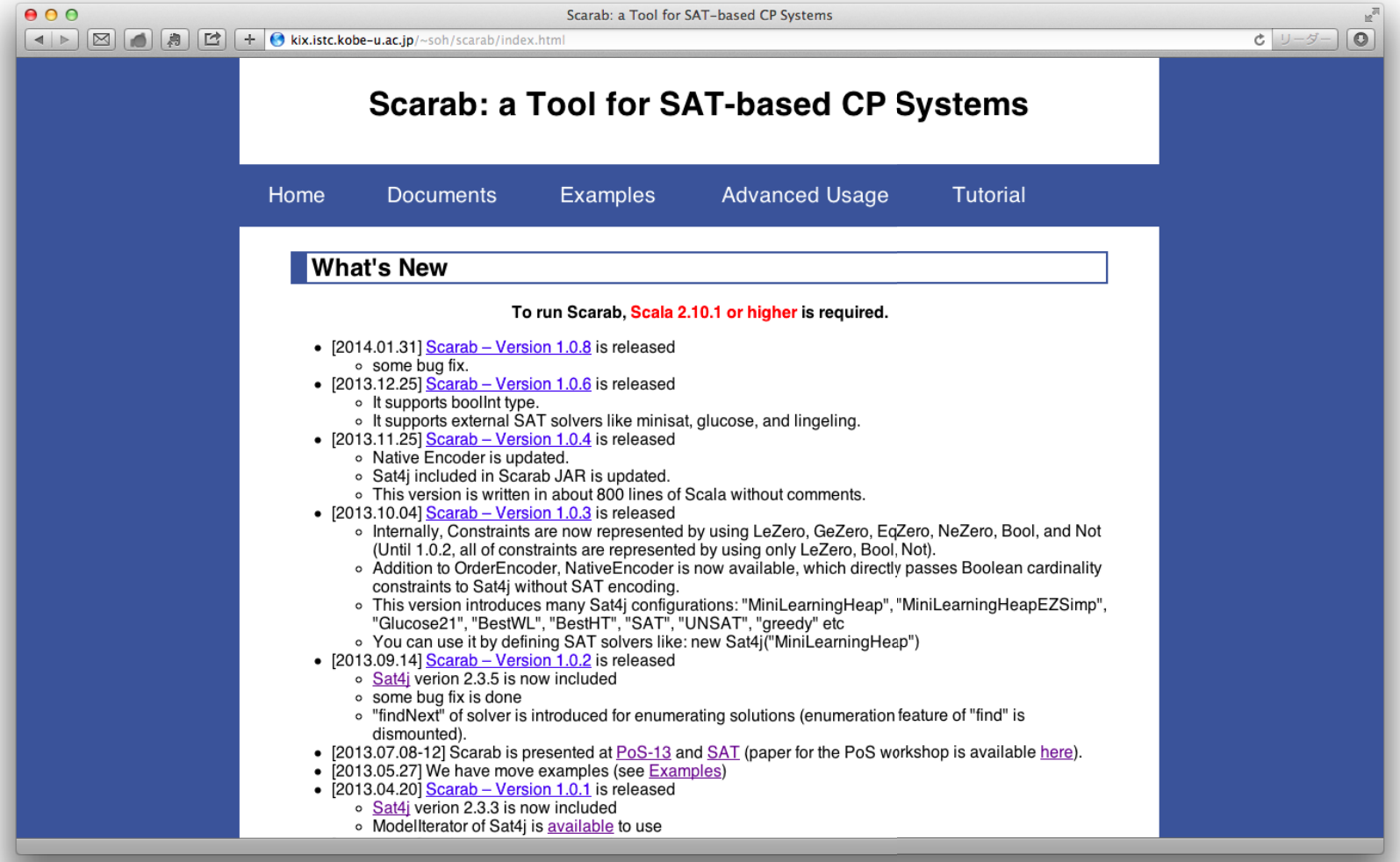
For Post-Enrollment Course Timetabling

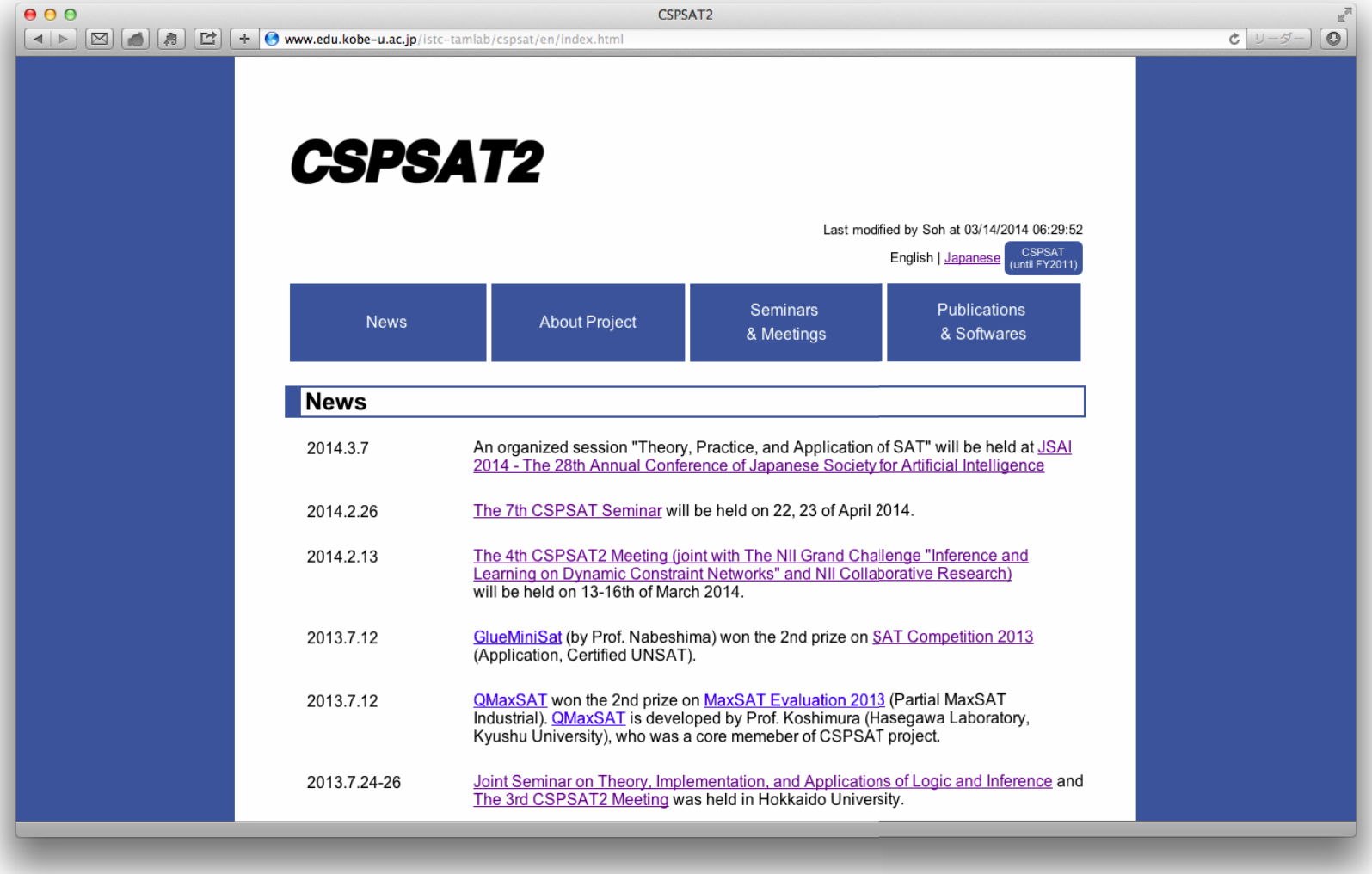


For Hamiltonian Cycle Problem

Web Page for Scarab

http://kix.istc.kobe-u.ac.jp/~soh/scarab/



Web Page for CSPSAT2

http://www.edu.kobe-u.ac.jp/istc-tamlab/cspsat/en/