TOWARDS SOLVING ESSENCE WITH LOCAL SEARCH: A PROOF OF CONCEPT USING SETS AND MULTISETS

Saad Attieh, Christopher Jefferson, Ian Miguel,
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LOCAL SEARCH

- Incomplete search, focus on finding good solutions fast.
- Use a set of moves (heuristics, neighbourhoods) to iteratively improve on the active solution.
- Choice of moves is most critical for performance, hence moves are usually very problem specific.
- Meta heuristics are used to select from set of moves, determines whether or not the new solution should be accepted.

ATHANOR

- Automated local search.
- Deduction of high quality neighbourhoods.
- Operates over very high-level specification.

ARE WE THE FIRST?

- Oscar CBLS
- Propagation guided, large neighbourhood search
- Explanation guided, large neighbourhood search
- All of these solvers derive their moves or neighbourhoods from analysis of the constraints in a problem.

THE PROBLEM OF AMBIGUOUS TYPES

find S : set (size 3) of int(1..5)

OCCURRENCE

find S : set (size 3) of int(1..5)

X1	X2	X3	X4	X5
0,1	0,1	0,1	0,1	0,1

sum(X[1..5])=3

S = {1,3,4}

X1	X2	X3	X4	X5
1	0	1	1	0

EXPLICIT

find S : set (size 3) of int(1..5)

Y1	Y2	Y3
1..5	1..5	1..5

alldiff(Y[1..3])

$S = \{1,3,4\}$

Y1	Y2	Y3
1	3	4

NEIGHBOURHOODS

$S = \{1,3,4\}$

X1	X2	X3	X4	X5
1	0	1	1	0

Y1	Y2	Y3
1	3	4

$S = \{1,2,4\}$

X1	X2	X3	X4	X5
1	1	0	1	0

Y1	Y2	Y3
1	2	4

CONSTRAINTS DON'T HELP MUCH

- alldiff([a,b,c,d,e])
- Is it a set,
- or an injective function,
- or part of a partition,
- etc.

ESSENCE: AN ABSTRACT CONSTRAINT SPECIFICATION LANGUAGE

- Distinguished by its support for variables with high level, arbitrarily nested types
- set, sequence, partition, set of sequence of tuple, multi set of partition….
- Models can be automatically refined for input to low level solvers.
    - SAT, CP, ILP
- Athanor needs no refinement, operates directly on the structures available in Essence

TWO KEY BENEFITS

EASY TO DERIVE SEMANTICALLY MEANINGFUL NEIGHBOURHOODS

- find S : set of int(1..5)
    - Add to s
    - remove from s
    - exchange one element for another
- find m : mset (maxSize 10) of set of int(1..5)
    - Select a single element of m and apply any of the above
    - Exchange elements between sets in m
    - Add sets to or remove sets from m

A FRAMEWORK FOR CONSTRAINT BASED LOCAL SEARCH USING ESSENCE

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DYNAMIC SCALING DDURING SEARCH

- find t : set of set of int(1..25)
- Usually represented as 2d matrix, requires 2^25 rows.
- Optimal value of set might be very small in comparison.
- Athanor understands that sets have a variable size and will dynamically allocate or deallocate memory accordingly.
- Athanor will also dynamically add and remove constraints as new elements are added or removed.
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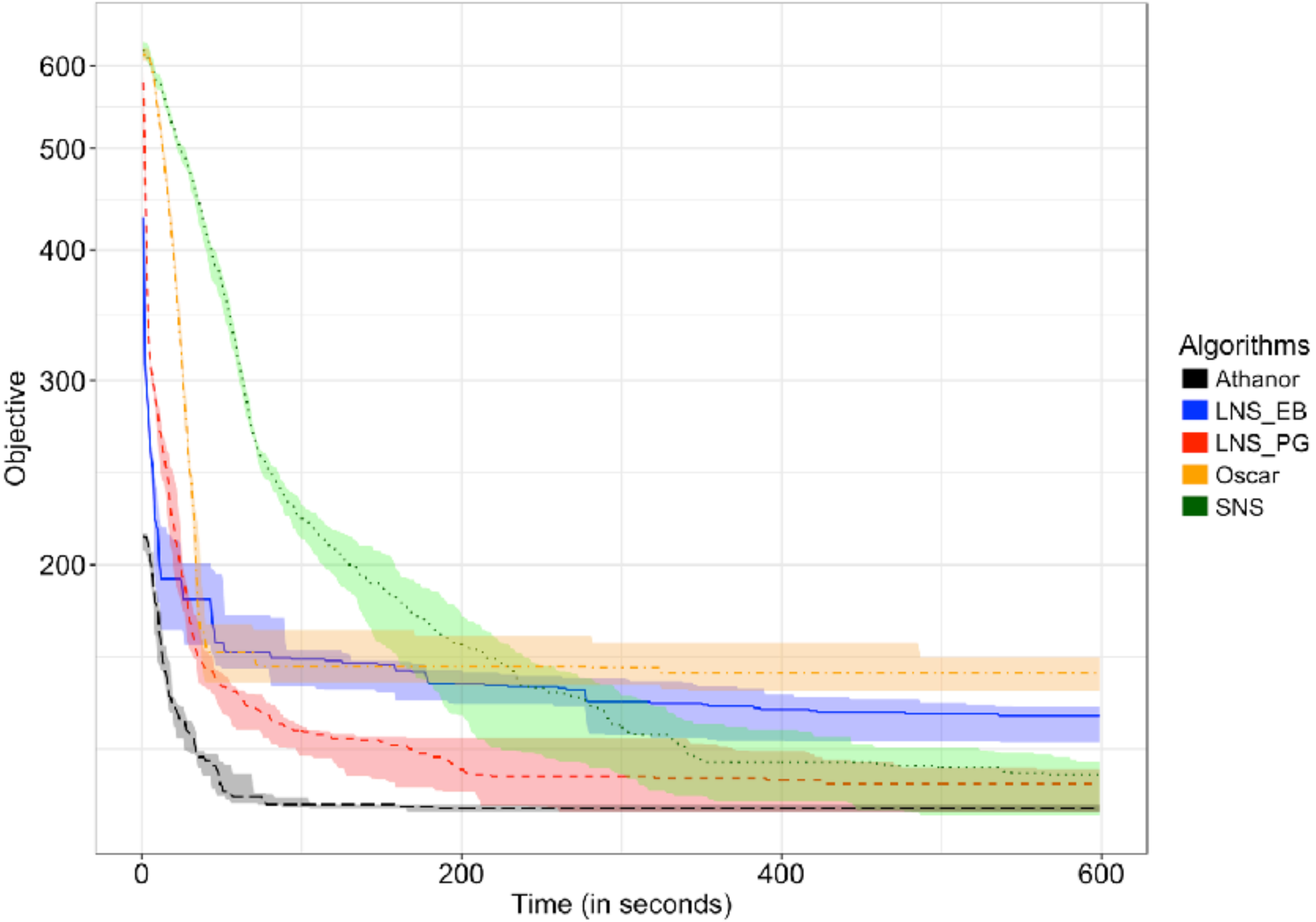
SONET, MULTISET OF SET



CONCLUSIONS

- Enhanced CBLS using abstract Essence types,
- Automatic construction of semantically meaningful neighbourhoods,
- Dynamic scaling,
- Strong performance shown with problems using sets and multisets.
- Read the paper and speak to me for more details:
  - Incremental evaluation, dynamic unrolling, more problem classes…