

# qmaiga: A combination of AIG based und search based QBF solvers

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qmaiga is a QBF solver for instances in prenex normal form. It loosely merges two orthogonal approaches of solving QBF instances. The core is an AIG based approach, AIGsolve[3]. In this process it is decided dynamically whether AIGsolve is stucked in a subproblem. In that case a searched based QBF solver, QMiraXT[2], take over the entire QBF instance.

## 1 QBF Preprocessing

The preprocessing first apply heuristic subsumption check, trivial unit propagation and pure literal techniques, followed by an exhaustive procedure including for-all reduction, equivalence reduction and also complete versions of subsumption, unit propagation und pure literal detection.

## 2 AIGsolve

AIGsolve consists – besides the preprocessing routine which is basically the exhaustive part of the QBF preprocessing described before – of three phases. The first phase is *structure extraction*. In this phase functional definitions in the clause set are identified. For these definitions an AIG is build, thus we receive a non-CNF representation of the QBF. In the next phase the quantifiers are “pushed” into the QBF matrix. This creates a tree-shaped CNF formula. This phase is called *early quantification*. The last and core phase of the solver is *symbolic quantifier elimination*. Here, the tree-shaped CNF formula is traversed, creating AIG representations for all sub-formulas. The quantors are eliminated by AIG operations. If all quantifiers are eliminated the resulting AIG leading to the result of the QBF instance.

## 3 QMiraXT

QMiraXT is a search based solver based on a DPLL[1] algorithmn with well-known techiques, e.g. boolean constraint propagation, non-chronological backtracking and wachted literals. The preprocessor can additionally handle UPLA technique and variable elimination. QMiraXT is able to handle multiple threads, due to the constraints of the competition a single thread version is used.

## 4 Combination

The core of the qmaiga solver is an AIGsolve version. In addition qmaiga decides dynamically whether AIGsolve is stucked into a subproblem of the QBF. If so the whole QBF instance – before the destruction of the CNF formula with AIGsolve – is passed to QMiraXT including the additional preprocessing techniques. This can handle QBF instances which AIGsolve is not able to solve and supplementary QMiraXT benefits from preprocessing steps performed before.

## References

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3. Florian Pigorsch and Christoph Scholl. Exploiting structure in an aig based qbf solver. In *DATE*, pages 1596–1601. IEEE, 2009.