C32SAT: Checking C Expressions

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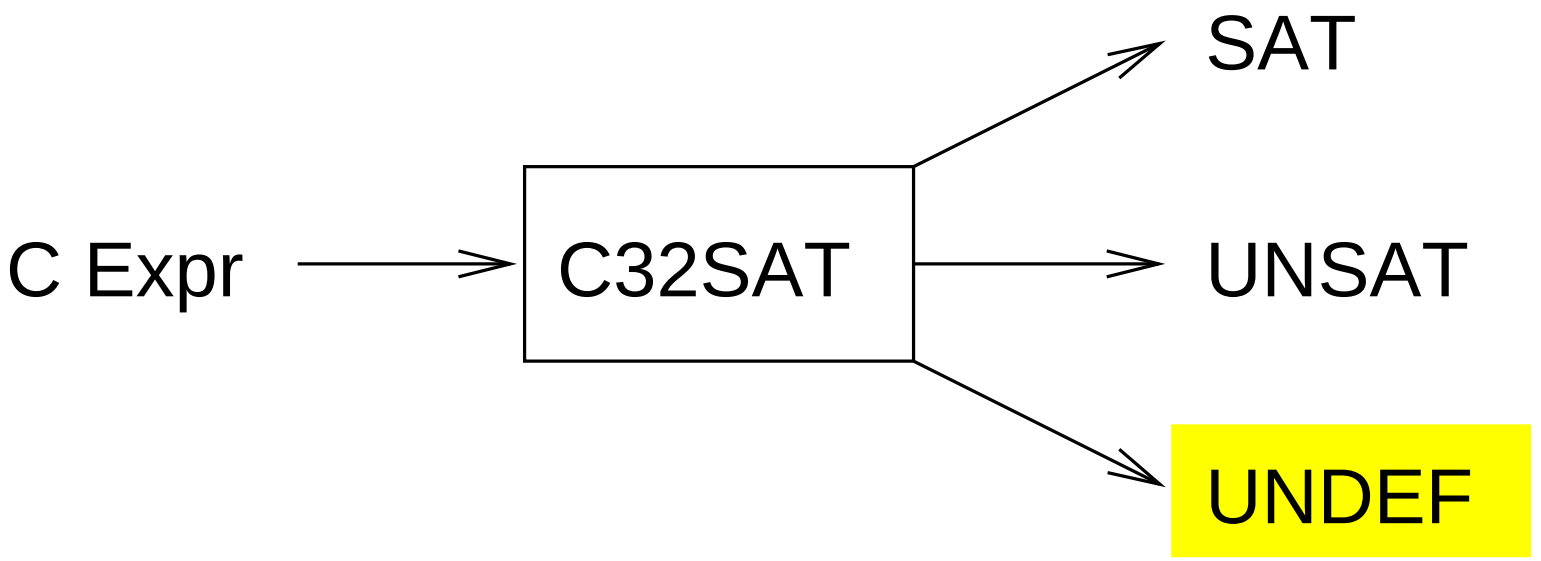

Undefinedness in C

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- Undefined behavior upon
  - Overflow
  - Division by zero
  - Shift by a negative integer
  - Shift by an integer $\geq$ bit width
  - ...
- Semantics depend on the compiler
- Portability and security issues

Addition Overflow

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$$x + y$$

0	1	1	1	1	1	1	1	$= 127$

$+$

0	0	0	0	0	0	0	1	$= 1$

$=$

1	0	0	0	0	0	0	0	$= -128$

Division Overflow

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```
y != 0 && x / y
```

Division Overflow

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```
y != 0 && x / y
```

1	0	0	0	0	0	0	0	$= -128$

$/$

1	1	1	1	1	1	1	1	$= -1$

$=$

1	0	0	0	0	0	0	0	$= -128$

Internal insights

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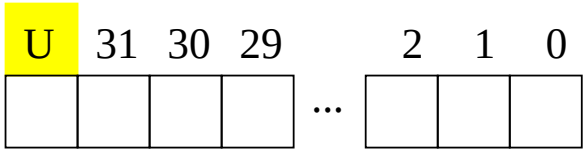
- Internal representation by vectors of And-Inverter Graphs (AIGs)
- Functional instead of relational representation
- One additional AIG per AIG vector represents “undefinedness”



- Expr. is undefined if some sub-expr. is undefined (except short circuit)
- Bit blasting to SAT solver (PicoSAT)

Division Overflow AIG (AIGER Format, 8 bits)

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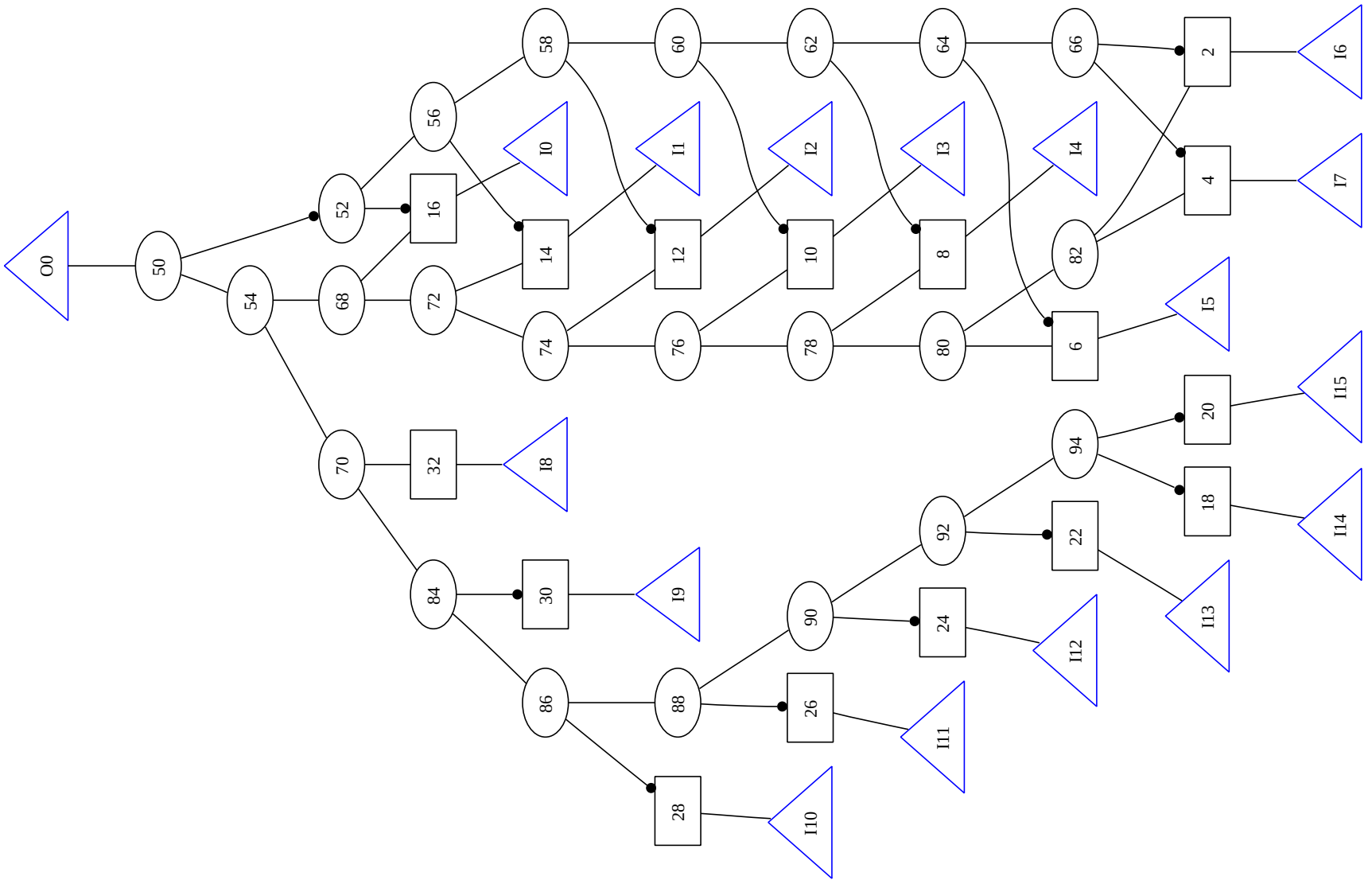

Optimization techniques

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- Boolean range analysis
  - Check if only boolean operators are applied to variable
- Local two-level AIG rewriting [BrummayerBiere, MEMICS'06]
  - Guaranteed to be globally size decreasing
- Under-approximation [Bryant et al., TACAS'07]
  - Restrict number of AIGs for encoding
  - If UA formula is SAT, then also original formula is SAT
  - If UA formula is UNSAT, then refine approximation

Under-approximation

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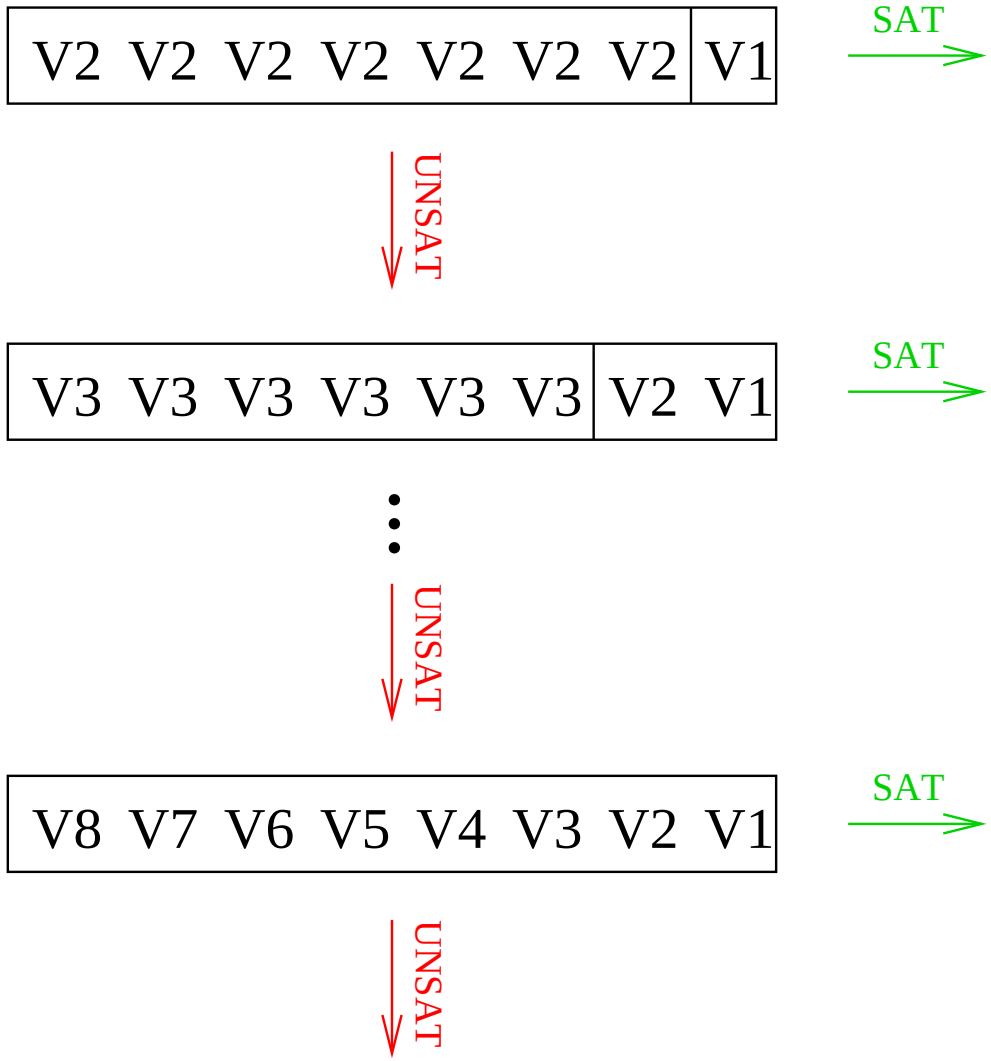

Conclusion

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- Checking “undefinedness” (ISO/IEC C99)
- Functional representation
- Optimizations
- Future work
  - Pointers
  - Over-approximation
  - Incremental API