Constraint Solvers for the Working PL Researcher

Nadia Polikarpova

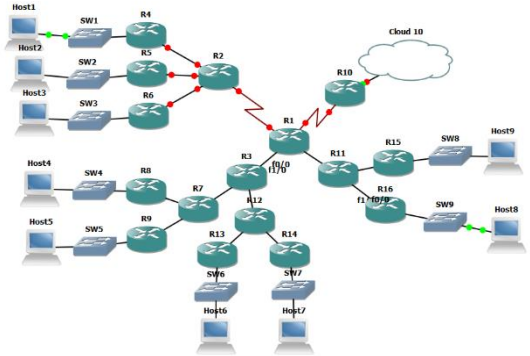
UCSDCSE
Computer Science and Engineering

The SAT/SMT Revolution

hardware verification

software verification

software synthesis & repair



network configuration synthesis

biological modeling

architecture

Boolean SATisfiability

$$(\text{gin} \vee \text{tonic}) \wedge (\text{minor} \Rightarrow \neg\text{gin}) \wedge \text{minor}$$

Solution:

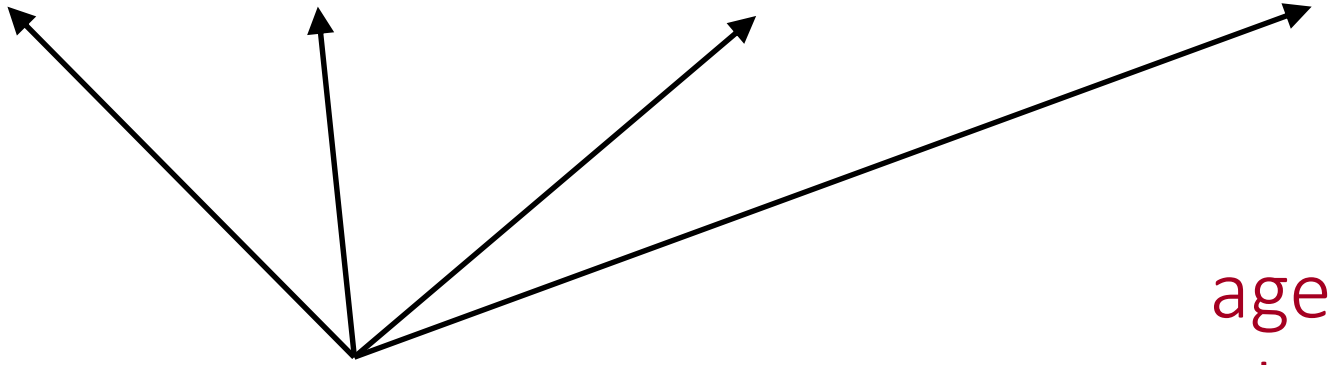
$\text{minor} \mapsto \text{T}$

$\text{gin} \mapsto \text{F}$

$\text{tonic} \mapsto \text{T}$

Satisfiability Modulo Theories

$$(\text{gin} \vee \text{tonic}) \wedge (\text{age} \leq 21 \Rightarrow \text{abv} = 0) \wedge (\text{age} = 17) \wedge (\text{gin} \Rightarrow \text{abv} \geq 40)$$



theory of Linear Integer Arithmetic

$\text{age} \mapsto 17$

$\text{abv} \mapsto 0$

$\text{gin} \mapsto \text{F}$

$\text{tonic} \mapsto \text{T}$

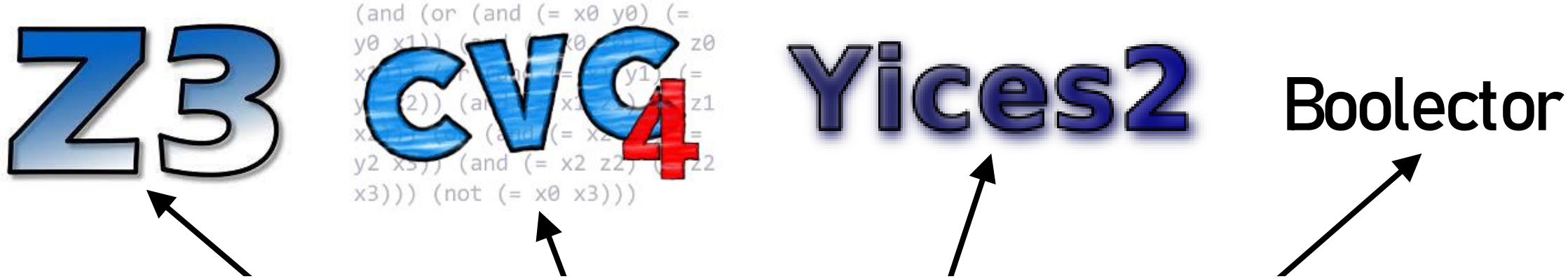
Popular Solvers

Microsoft

Stanford

SRI

JKU Linz, Austria



SMT competition: http://smtcomp.sourceforge.net

```
.smt2                    // SMTLib format

(declare-fun (Int) age)
(declare-fun (Int) abv)
```

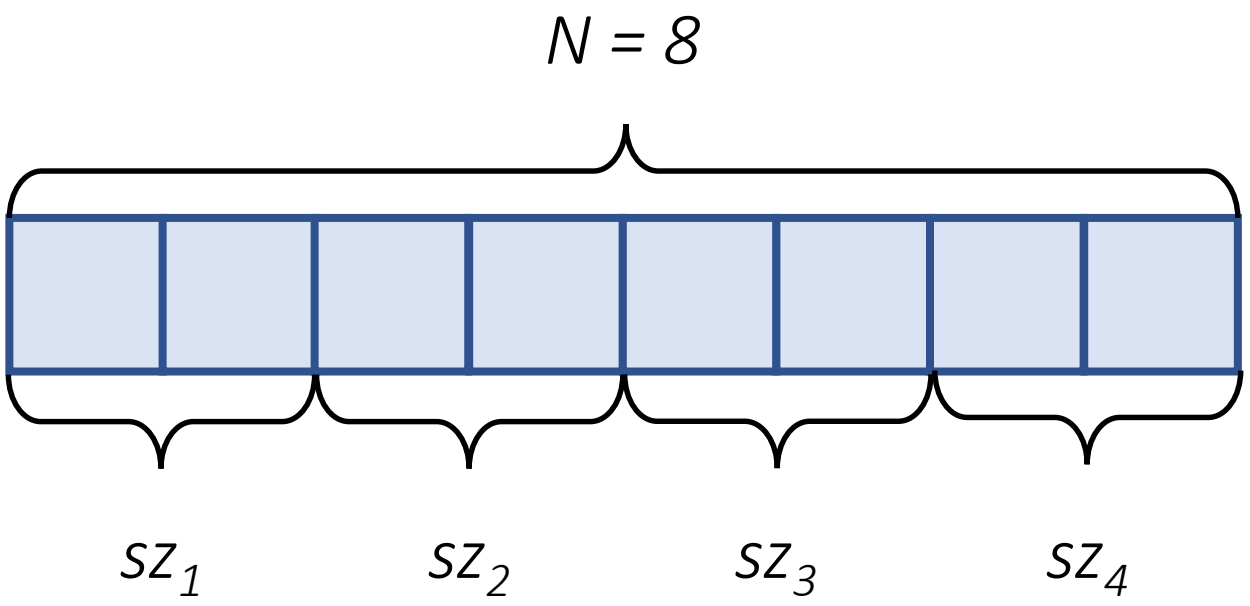
Plan for Today

How to use Z3 for:

1. Constraint programming
2. Program verification
3. Program synthesis

Problem: Array Partitioning

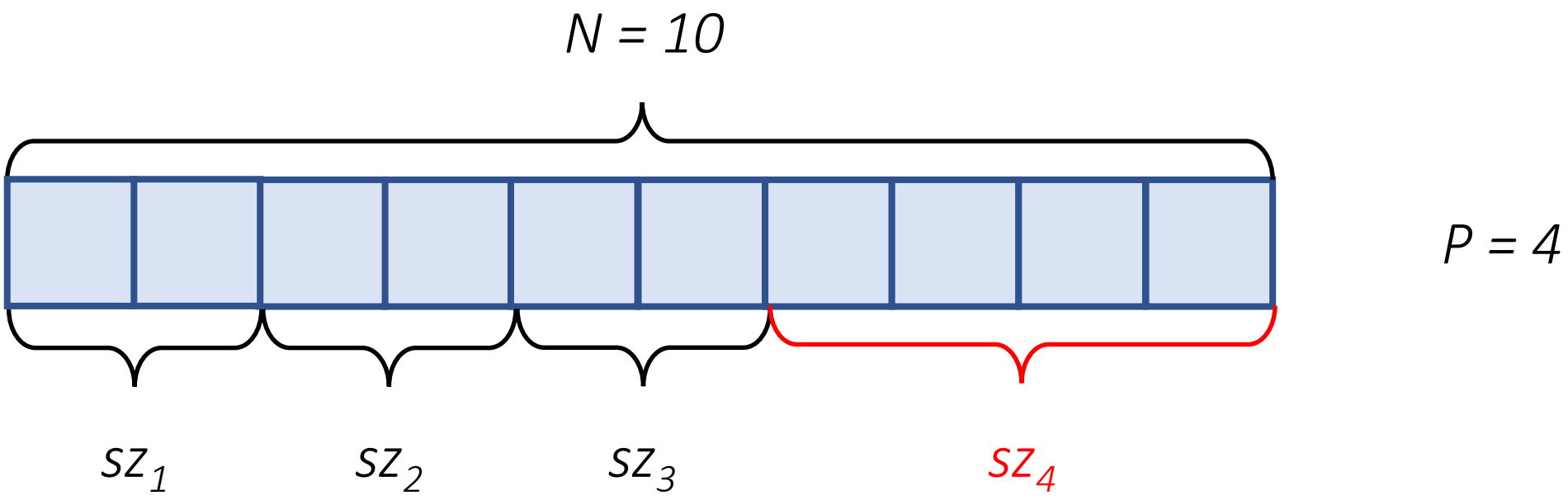
Partition an array of size *N* evenly into *P* sub-ranges



P = 4

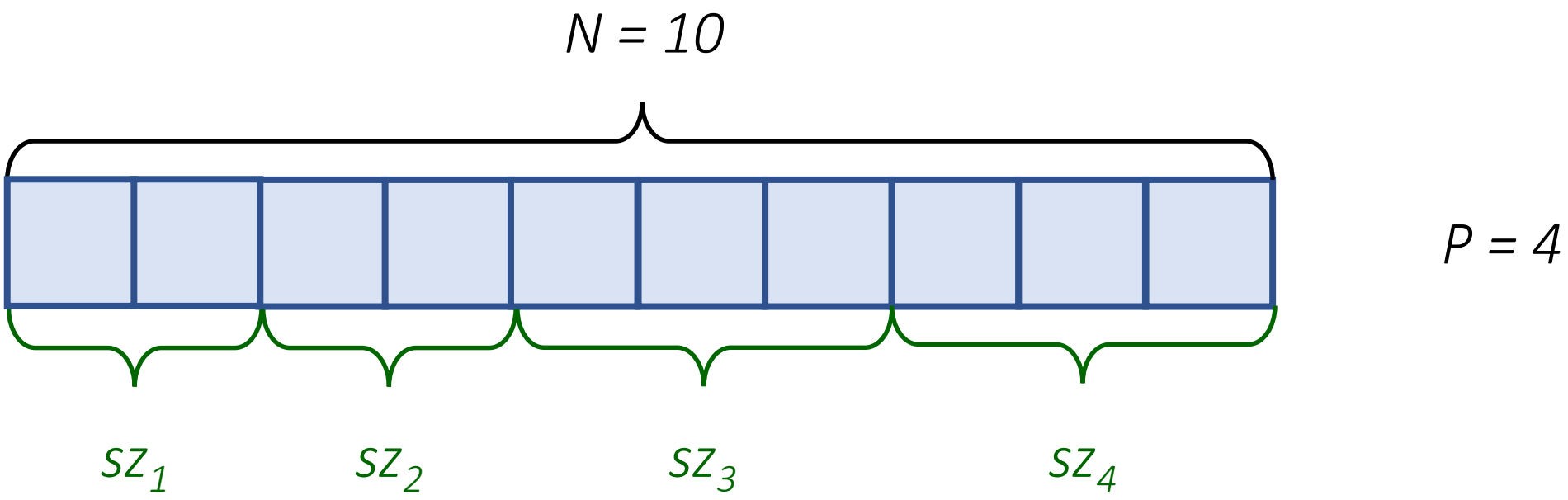
Problem: Array Partitioning

Partition an array of size *N* evenly into *P* sub-ranges



Problem: Array Partitioning

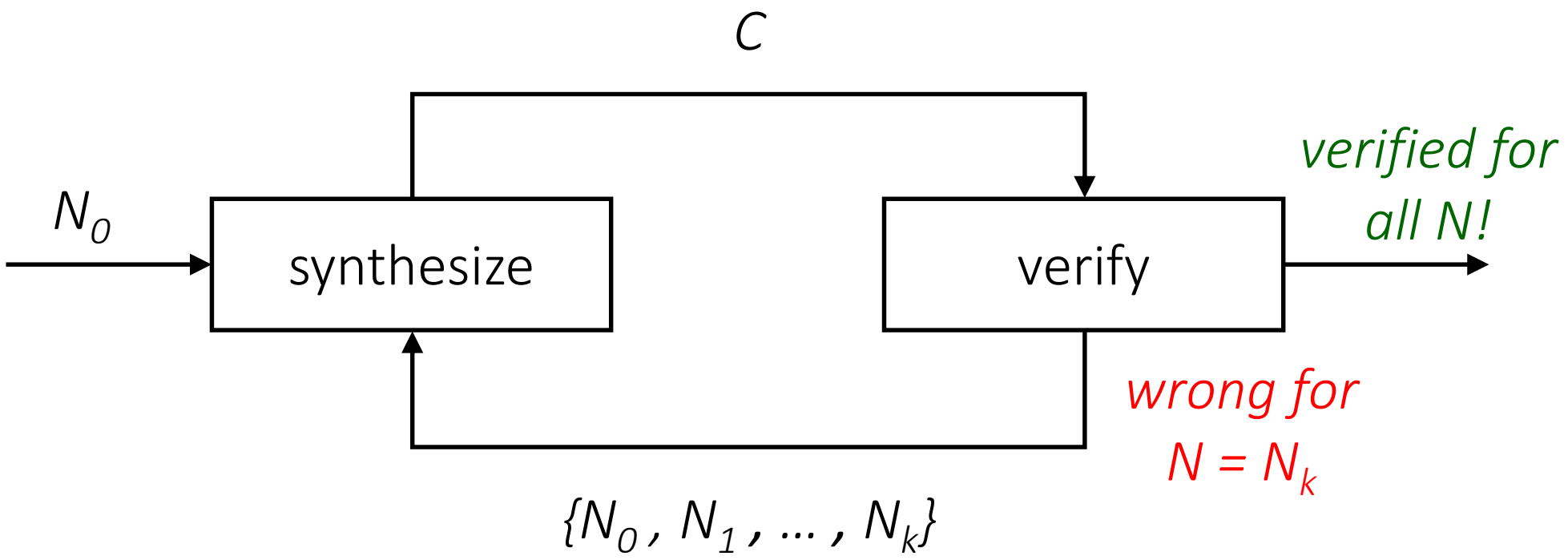
Partition an array of size *N* evenly into *P* sub-ranges



Can we always make them differ by at most 1?

to the rescue!

CEGIS


C
N_0
synthesize
verify
verified for all N!
wrong for $N = N_k$
$\{N_0, N_1, \ldots, N_k\}$