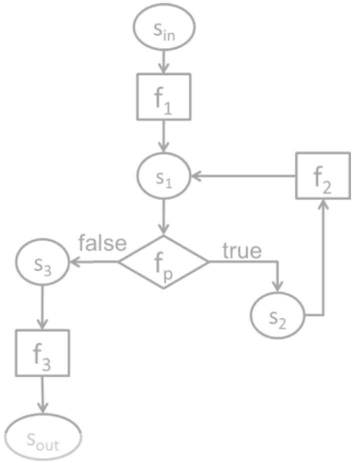
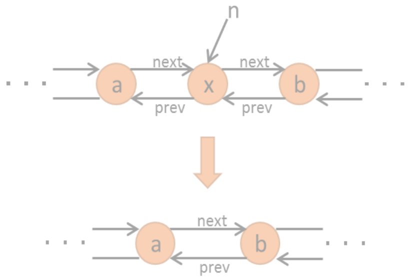
$\exists c \forall in \; Q(c, in)$

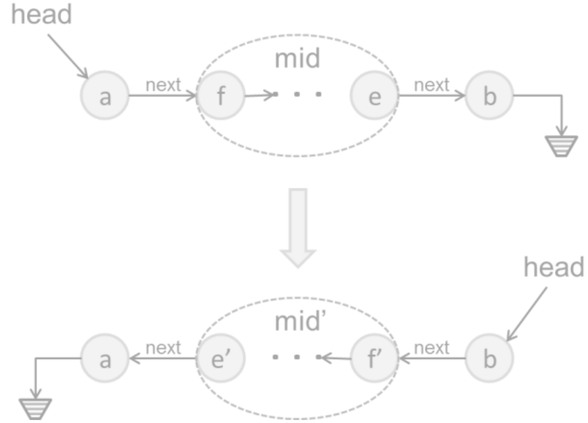
```
/* Average of x and y without using x+y (avoid overflow)*/
int avg(int x, int y){
  int t = expr({x/2, y/2, x%2, y%2, 2 }, {PLUS, DIV});
  assert t == (x+y)/2;
  return t;
}
```

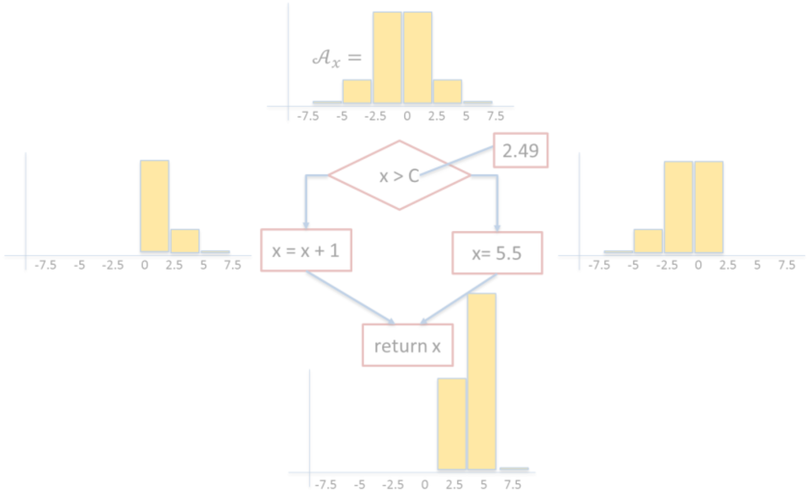




```
{
   s  = n.succ;
   p = n.pred;
   p.succ = s;
   s.pred = p;
}
```

Unit III: Applications of Synthesis





$\varphi(p)$

$Sk[c](in)$

Logistics

Project presentations

- One team presenting next week (Team 6), others present on Dec 11
- 20 min per team (15 min presentation + questions)
- Structure: motivation, **demo**, technique, evaluation

Project reports

- Due on Dec 13 (start working on them now!)
- Format: see course organization page (3-5 pages, SIGPLAN format)

Next week

- Tuesday: Team 6 presentation, discuss remaining papers
- Thursday: no class (project hacking time!)

Lecture 16
Superoptimization and Data Wrangling

Nadia Polikarpova

Scaling up superoptimization

[Phothimilthana et al. '16]

What is the problem the paper is trying to solve?

- Why is it important?
- What are existing approaches to this problem?

Synthesis technique

- What are the behavioral constraints?
- Structural constraint?
- Search strategy?

What are the contributions of the paper?

Scaling up superoptimization

[Phothimilthana et al. ‘16]

Discuss each pruning technique of Lens and compare with other synthesizers

- Incremental observational equivalence
- Bidirectional search
- Reduced bit witdth

Discuss the strengths of cooperative search

What are the limitations of the presented technique?

- Can it be extended to branches / loops?
- Compare with related work (STOKE)

Morpheus

[Feng et al. ‘17]

What is the problem the paper is trying to solve?

- Why is it important?
- What are the main challenges?

Synthesis technique

- What are the behavioral constraints?
- Structural constraint?
- Search strategy?

What are the contributions of the paper?

Morpheus

[Feng et al. ‘17]

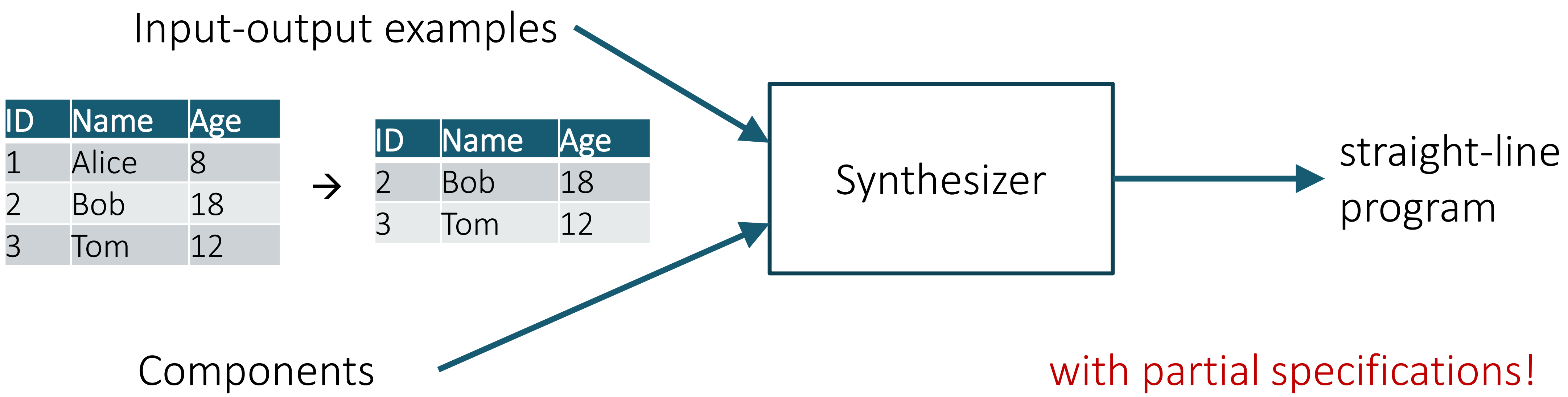
Discuss pruning techniques in Morpheus and compare them to other tools

- type-directed search
- lightweight deduction
- partial evaluation

What are the limitations of the presented technique?

Morpheus: TDP with deduction

[Feng et al‘17]



ID	Name	Age
1	Alice	8
2	Bob	18
3	Tom	12

→

ID	Name	Age
2	Bob	18
3	Tom	12

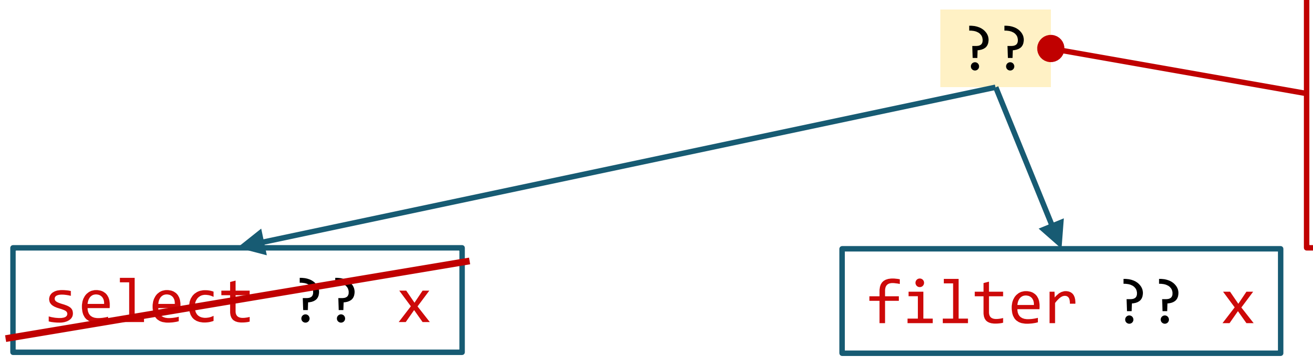
with partial specifications!

```
select : Table → [Col] → Table                ensures out.rows = in.rows
                                              && out.cols < in.cols

filter : Table → (Row → Bool) → Table         our.rows < in.rows
                                              && out.cols = in.cols
```

Morpheus: TDP with deduction

[Feng et al‘17]



??

~~select ?? x~~

filter ?? x

x

ID	Name	Age
1	Alice	8
2	Bob	18
3	Tom	12

→

y

ID	Name	Age
2	Bob	18
3	Tom	12

$$\begin{aligned}\exists x\ y : y.\mathrm{rows} = x.\mathrm{rows} \land y.\mathrm{cols} < x.\mathrm{cols}\\ \land\, x.\mathrm{rows} = 3 \land x.\mathrm{cols} = 3\\ \land\, y.\mathrm{rows} = 2 \land y.\mathrm{cols} = 3\end{aligned}$$

$$\Big\downarrow \text{SMT}$$

UNSAT

$$\begin{aligned}\exists x\ y : y.\mathrm{rows} < x.\mathrm{rows} \land y.\mathrm{cols} = x.\mathrm{cols}\\ \land\, x.\mathrm{rows} = 3 \land x.\mathrm{cols} = 3\\ \land\, y.\mathrm{rows} = 2 \land y.\mathrm{cols} = 3\end{aligned}$$

$$\Big\downarrow \text{SMT}$$

SAT

```
select : Table → [Col] → Table
filter : Table → (Row → Bool) → Table
```

```
out.rows = in.rows && out.cols < in.cols
our.rows < in.rows && out.cols = in.cols
```