

hexaly

! d 1 @ E J g H i Δ T L È i Δ T š G J È H G d J g 1 Z H G d > 1 W i È H
% d g % d S S Δ S f i È i È S T
J S È O È È R H È Δ J = % È 1 4 % È 1 Δ ç i o @ ""

ç L š G È i Δ d g È
G 1 Δ d g È d Z È R Δ 1 4 " f i d i

o o o " L È R Δ 1 4 " f i d i

LocalSolver

— is now —

hexaly

We're excited to share that we are moving forward. We're leaving behind the LocalSolver brand and transitioning to our new identity: Hexaly. This represents a leap forward in our mission to enable every organization to make better decisions faster when faced with operational and strategic challenges.

Mathematical solvers for scheduling problems

Mathematical solvers for scheduling problems

5 J H S E H H G d > 1 Z I

5 J H S E H H H d 1 4 T S S



$$f(x)$$



Mathematical solvers for scheduling problems

$$H \pm D \approx \mu \pm D \gg \mu \pm D$$

WETEGD ESEdJH

- $\hat{i} \text{ EÖEg} \Delta \hat{r} \text{ GEHd} \cdot \text{gEHdJgiEH} \cdot \% \hat{H} \hat{J} \hat{S} \hat{f} \hat{i} \hat{T} \hat{S} \hat{O} \hat{E} \hat{T} \hat{i} \hat{J} \hat{i} \hat{J} \hat{1} \hat{\Delta} \hat{T} \hat{S} \hat{O} \hat{E} \hat{T} \hat{d} \hat{g} \hat{E} \hat{H}$
- $\hat{e} \text{EHdJgiE} \Delta \hat{f} \hat{i} \hat{\Delta} \hat{T} \hat{S} \hat{S} \% \hat{E} \hat{f} \hat{i} \hat{S} \hat{H} \hat{S} \hat{H}$
- $\langle \hat{s} \cdot \hat{E} \hat{g} \hat{E} \hat{S} \hat{T} \hat{T} \hat{r} \hat{G} \hat{E} \hat{H} \hat{d} \cdot \hat{f} \hat{i} \hat{d} \hat{S} \hat{H} \hat{i} \hat{g} \hat{S} \hat{T} \hat{H} \hat{T} \hat{E} \hat{i} \hat{G} \hat{d} \hat{g} \hat{\Delta} \hat{f} \hat{i} \hat{\Delta} \hat{T} \hat{S} \% \hat{\Delta} \hat{g} \hat{H} \hat{T} \hat{E} \hat{T} \hat{J} \hat{G} \hat{T} \hat{S} \hat{E} \hat{H}$
- $\hat{i} \text{ EÖEg} \Delta \hat{r} \text{ GEHd} \cdot \hat{d} \cdot \hat{1} \hat{E} \hat{f} \hat{i} \hat{T} \hat{S} \hat{O} \hat{E} \hat{H} \hat{T} \hat{\Delta} \hat{g} \% \hat{S} \hat{E} \hat{H} \hat{H} \hat{\Delta} \hat{f} \hat{i} \hat{\Delta} \hat{T} \hat{S} \hat{S} \hat{f} \hat{i} \hat{d} \hat{H} \hat{i} \hat{H} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{H} \hat{E} \hat{T} \hat{J} \hat{G} \hat{f} \hat{i} \hat{d} \hat{H} \hat{i} \hat{H}$

i Δg E

- $\hat{i} \hat{d} \hat{i} \hat{E} \hat{G} \hat{d} \cdot \hat{1} \hat{Z} \hat{i} \hat{H} \hat{o} \hat{s} \hat{L} \hat{J} \hat{G} \hat{T} \hat{d} \hat{S} \hat{I} \hat{V} \hat{I} \hat{r} \hat{r} \hat{r} \hat{r} \hat{\Delta} \hat{f} \hat{i} \hat{T} \hat{S} \hat{O} \hat{E} \hat{H} \hat{T} \hat{r} \hat{r} \hat{r} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{H}$
- $\hat{O} \hat{S} \hat{E} \cdot \hat{g} \hat{\Delta} \hat{S} \cdot \hat{g} \hat{\Delta} \hat{S} \hat{J} \hat{\Delta} \hat{g} \hat{r} \hat{d} \cdot \hat{T} \hat{S} \hat{E} \hat{T} \hat{r} \hat{G} \hat{E} \hat{i} \hat{\Delta} \hat{f} \hat{i} \hat{o} \hat{I} \hat{V} \hat{I} \hat{r} \hat{r} \hat{r} \hat{r} \hat{T} \hat{S} \hat{E} \hat{G} \hat{d} \hat{S} \hat{T} \hat{H}$

† HÛ Δ₄ "h z τ EfiL Sd₁₄ r % dEH Sd₁ Hi Δ₂ o E₁₄ S TL EHE Ggd > 1Zi H

- $n \Delta \hat{S} \hat{S} \hat{E} \hat{H} \cdot \hat{d} \hat{g} \hat{J} \hat{1} \hat{\Delta} \hat{T} \hat{S} \hat{S} \cdot \hat{d} \hat{g} \% \hat{H} \hat{J} \hat{S} \hat{f} \hat{i} \hat{T} \hat{S} \hat{O} \hat{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{H} \hat{u} \hat{S} \hat{e}$ Jrrr rrr rrr rrr
- $\langle \hat{s} \hat{f} \hat{i} \hat{g} \hat{E} \hat{T} \hat{E} \hat{T} \hat{S} \hat{E} \cdot \hat{d} \hat{g} \hat{J} \hat{1} \hat{\Delta} \hat{T} \hat{S} \hat{S} \hat{H} \hat{\Delta} \hat{g} \hat{E} \hat{S} \hat{u} \hat{S} \hat{o} \hat{d}$ Jrrr rrr rrr rrr

Mathematical solvers for scheduling problems

$\wedge \hat{u} \approx \mu \dagger \hat{u} \approx \hat{u} / \hat{E} \cdot \mu \hat{U} \approx$

Qđđ₊ E₊ĤĤi E₊ŞĤΔ₊Ĝ₊ ĤiĤđđ₊¼

- | | | |
|--|--|-----------------------------------|
| • oĤi > EĝĤ ₊ | J ₊ "ε ₊ "3 ₊ " ₊ | J ₊ ŝ |
| • 6đđ ĜΔĝĤđŞ > E ₊ Ĥō EĤĤŞŞĤĤi > EĝĤ ₊ | ε ₊ IX ₊ l ₊ | J ₊ ŝIXêW |
| • %%ăăđŞĤΔ 1ĤĤ ₊ | ε ₊ K ₊ 3 ₊ IV ₊ f | SJ ₊ ŝ |
| • n J ₊ 1ĤĤĤi ΔĤđŞĤΔ 1ĤĤ ₊ | ε ₊ 3 ₊ IV ₊ † | S Δ ₊ J ₊ ŝ |

↳ n Z₊

Mathematical solvers for scheduling problems

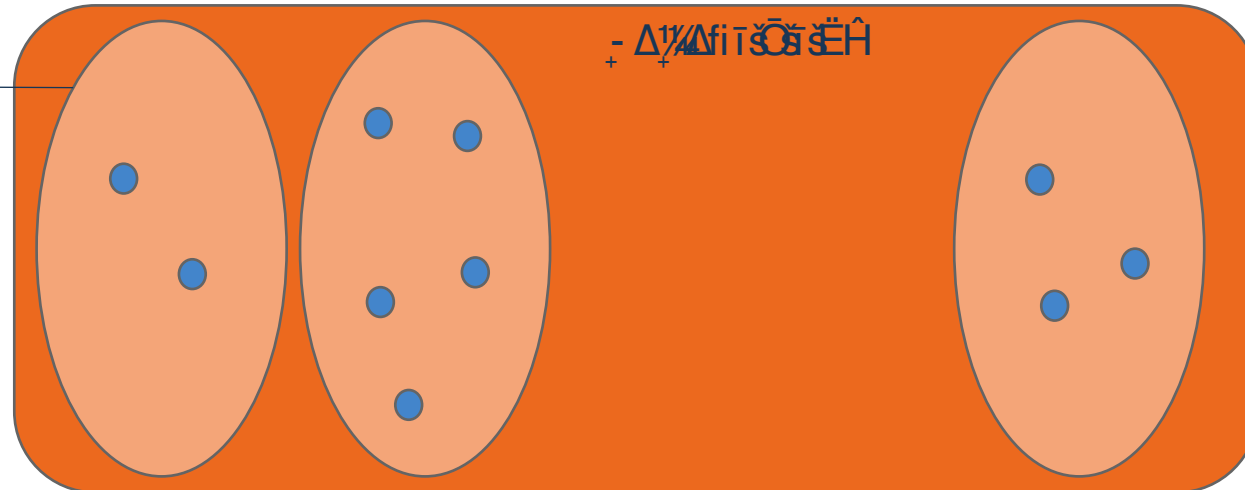
$\wedge \hat{u} \approx \mu \dagger \hat{u} \hat{s} \hat{u} / \hat{E} \cdot \mu \hat{U} \hat{s}^{\circ}$

Opt. $\hat{E} \hat{f} \hat{i} \hat{d} \hat{s} \% \Delta \hat{g} \hat{r} \hat{H} \hat{i} \hat{L} \hat{d} \hat{d} \hat{1} \hat{4}$

- $\hat{I} \hat{E} \hat{T} \hat{H}$

$\hat{J} \in \hat{a} \hat{a} \subseteq 5 \hat{G} \hat{A} \hat{g} \hat{i} \hat{s} \hat{s} \hat{t} \hat{s} \hat{5} \hat{s}$

$5 \hat{L} \hat{\Delta} \hat{f} \hat{i} \hat{T} \hat{S} \hat{O} \hat{s} \hat{E} \hat{H} \hat{d} \hat{s}$
 $\hat{I} \hat{\Delta} \hat{f} \hat{i} \hat{L} \hat{S} \hat{E} \hat{n} \hat{J}$



Mathematical solvers for scheduling problems

$\hat{u} \approx \mu \dagger \hat{u} \approx \hat{u} / \hat{E} \cdot \mu \hat{U} \approx$

$\hat{Q} \hat{d} \hat{I} \hat{H} \hat{E} \hat{f} \hat{i} \hat{d} \hat{S} \% \hat{\Delta} \hat{g} \hat{H} \hat{i} \hat{L} \hat{d} \hat{d} \hat{1} \hat{4}$

- $\hat{I} \hat{E} \hat{T} \hat{H}$
- $\hat{c} \hat{E} \hat{g} \hat{J} \hat{T} \hat{\Delta} \hat{T} \hat{s} \hat{S} \hat{H}$

$\hat{J} \in \hat{a} \hat{a} \subseteq 5 \hat{G} \hat{\Delta} \hat{g} \hat{i} \hat{s} \hat{s} \hat{S} \hat{5} \hat{s}$
 $\hat{I} \hat{c} \hat{E} \hat{g} \hat{J} \hat{T} \hat{\Delta} \hat{T} \hat{s} \hat{S} \hat{H}$

Mathematical solvers for scheduling problems

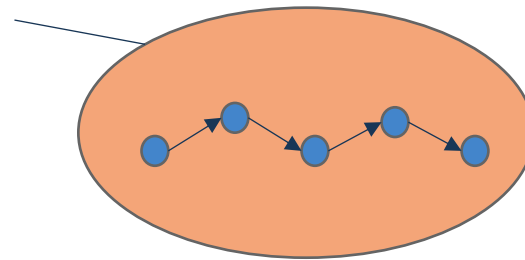
$\wedge \hat{u} \approx \mu \dagger \hat{u} \approx \hat{u} / \hat{E} \cdot \mu \hat{U} \hat{s}^{\circ}$

$\hat{Q} \hat{d} \hat{i} \hat{+} \hat{H} \hat{E} \hat{i} \hat{d} \hat{S} \% \hat{\Delta} \hat{g} \hat{+} \hat{H} \hat{i} \hat{L} \hat{d} \hat{d} \hat{1} \hat{4}$

- $\hat{i} \hat{E} \hat{i} \hat{H}$
- $\hat{c} \hat{E} \hat{g} \hat{J} \hat{T} \hat{\Delta} \hat{i} \hat{s} \hat{S} \hat{H}$

$\hat{+} \hat{J} \hat{E} \hat{+} \hat{a} \hat{a} \hat{+} \hat{+} \hat{\subseteq} \hat{5} \hat{+} \hat{G} \hat{\Delta} \hat{g} \hat{i} \hat{s} \hat{s} \hat{S} \hat{+} \hat{5} \hat{s} \hat{+} \hat{-}$
 $\hat{i} \hat{+} \hat{+} \hat{E} \hat{i}$

$\hat{i} \hat{-} \hat{H} \hat{E} \hat{G} \hat{J} \hat{E} \hat{s} \hat{i} \hat{E} \hat{d} \hat{+}$
 $\hat{\Delta} \hat{i} \hat{s} \hat{O} \hat{i} \hat{E} \hat{H} \hat{d} \hat{S} \hat{+}$
 $\hat{\Delta} \hat{i} \hat{\Delta} \hat{i} \hat{L} \hat{s} \hat{E} \hat{n} \hat{+}$



Mathematical solvers for scheduling problems

$\wedge \hat{u} \approx \mu \dagger \hat{u} \approx \hat{u} / \hat{E} \cdot \mu \hat{U} \hat{s}^\circ$

$Q_{\text{opt}} \hat{H} \hat{E} \text{id} \hat{S} \% \Delta \hat{g} \hat{H} \text{i} \text{L} \text{d} \text{d} \text{1} \text{4}$

- $\hat{I} \hat{E} \text{i} \hat{H}$
- $\hat{c} \hat{E} \text{j} \hat{J} \text{T} \Delta \text{T} \hat{s} \hat{S} \hat{H}$
- $\hat{Z} \text{T} \hat{E} \hat{g} \hat{O} \Delta \text{1} \text{4}$

$\hat{J} \in \hat{a} \hat{a} \subseteq 5 \hat{G} \Delta \text{j} \hat{s} \hat{s} \hat{S} \hat{5} \hat{s}$

$\hat{I} \hat{c} \in \hat{I}$

$\hat{R} \text{IV} \hat{J} \hat{O} \hat{c} \in \hat{R}$

Mathematical solvers for scheduling problems

$\wedge \hat{u} \approx \mu \dagger \hat{u} \checkmark \hat{u} / \hat{E} \cdot \mu \hat{U} \checkmark$

$Q \hat{d} \hat{I} \hat{H} \checkmark \hat{E} \hat{f} \hat{i} \hat{d} \hat{S} \% \hat{\Delta} \hat{g} \hat{r} \hat{H} \hat{i} \hat{L} \hat{d} \hat{d} \hat{1} \hat{4}$

- $\hat{I} \hat{E} \hat{T} \hat{H}$
- $\checkmark \hat{E} \hat{g} \hat{J} \hat{T} \hat{\Delta} \hat{T} \hat{s} \hat{S} \hat{H}$
- $\checkmark \hat{T} \hat{E} \hat{g} \hat{O} \hat{\Delta} \hat{1} \hat{4}$
- $Q \hat{J} \hat{S} \hat{f} \hat{i} \hat{T} \hat{s} \hat{S} \hat{H}$

$\hat{J} \in \hat{a} \hat{a} \subseteq 5 \hat{G} \hat{\Delta} \hat{g} \hat{r} \hat{s} \hat{s} \hat{S} \hat{5} \hat{s}$

$\hat{I} \hat{E} \hat{T} \hat{H}$

$\hat{R} \hat{I} \hat{V} \hat{J} \hat{O} \hat{T} \in \hat{R}$

\hat{T}

Mathematical solvers for scheduling problems

Επιλύσιμα προβλήματα

CP



u ∈ I, s ∈ Δ, t ∈ S, G ∈ G, 1 ∈ I

ή δ E_g

Mathematical solvers for scheduling problems

$E\mu \hat{U}S^e \hat{U}S^{\dagger} \hat{c}\mu \sim \wedge \hat{E}\pm\mu/\gg \hat{z}$

$\hat{o}\hat{l}\hat{E}\hat{W}\hat{E}\hat{R}\hat{\Delta}\hat{1}\hat{4}\hat{i} \hat{d}\% \hat{E}\hat{1}\hat{S}\hat{+} \hat{1}\hat{\Delta}\hat{S}\hat{+} \hat{J}\hat{\Delta}\hat{+} \hat{E}\hat{s}\hat{H}\hat{+} \hat{g}\hat{d}\hat{J}\hat{S}\hat{\%}\hat{E}\hat{\%}\hat{d}\hat{S}\hat{H}\hat{\ddot{H}} \hat{G}\hat{1}\hat{Z}\hat{i} \hat{\Delta}\hat{L}\hat{E}\hat{i} \hat{\Delta}\hat{T}\hat{s}\hat{i}\hat{\Delta}\hat{1}\hat{4}\hat{i}\hat{d}\hat{S}\hat{f}\hat{i}\hat{E}\hat{G}\hat{T}\hat{H}\hat{-}$

- $\hat{o}\hat{J}\hat{i} \hat{E}\hat{g}\hat{s}\hat{i}\hat{\Delta}\hat{1}\hat{4}\hat{g}\hat{s}\hat{\Delta} \hat{1}\hat{Z}\hat{H} \hat{5}\hat{d}\hat{d}\hat{1}\hat{Z}\hat{\Delta}\hat{S}\hat{+} \hat{S}\hat{T}\hat{E}\hat{+} \hat{E}\hat{g}\hat{+} \hat{1}\hat{4}\hat{\Delta}\hat{T}\hat{S}\hat{+} \hat{G}\hat{d}\hat{S}\hat{T}$
- $\hat{Z}\hat{S}\hat{T}\hat{E}\hat{g}\hat{\Delta}\hat{1}\hat{4}\hat{g}\hat{s}\hat{\Delta} \hat{1}\hat{Z}\hat{H}$
- $\hat{i} \hat{E}\hat{T} \hat{\Delta}\hat{g}\hat{s}\hat{\Delta} \hat{1}\hat{Z}\hat{H}$
- $\hat{i} \hat{s}\hat{H}\hat{+} \hat{G}\hat{E}\hat{g}\hat{i} \hat{J}\hat{T}\hat{\Delta}\hat{T}\hat{s}\hat{i}\hat{S}\hat{+} \hat{\Delta}\hat{g}\hat{s}\hat{\Delta} \hat{1}\hat{Z}\hat{H}$

$\hat{6} \hat{1}\hat{\Delta}\hat{H}\hat{H}\hat{\ddot{H}}\hat{i}\hat{\Delta}\hat{1}\hat{4}\hat{E}\hat{+} \hat{g}\hat{\Delta}\hat{s}\hat{i}\hat{\Delta}\hat{1}\hat{4}\hat{S}\hat{\%}\hat{1}\hat{4}\hat{+} \hat{s}\hat{i}\hat{\Delta}\hat{1}\hat{4}\hat{d}\hat{G}\hat{E}\hat{g}\hat{\Delta}\hat{T}\hat{d}\hat{g}\hat{H} \hat{H}\hat{U}\hat{i} \hat{+} \hat{i} \hat{S}\hat{+} \hat{\Delta}\hat{R}\hat{+} \hat{G}\hat{g}\hat{d}\hat{\%}\hat{\Delta}\hat{S}\hat{\%}\hat{d}\hat{g}\hat{-}$

$\hat{o}\hat{d} \hat{S}\hat{E}\hat{E}\hat{\%}\hat{d}\hat{d} \hat{s}\hat{S}\hat{T}\hat{g}\hat{d}\hat{\%}\hat{J}\hat{f}\hat{i}\hat{E}\hat{+} \hat{\Delta}\hat{+} \hat{g}\hat{E}\hat{+} \hat{\Delta}\hat{T}\hat{E}\hat{\%}\hat{f}\hat{i}\hat{d}\hat{S}\hat{H}\hat{i}\hat{g}\hat{J}\hat{f}\hat{i}\hat{T}\hat{H}\hat{+} \hat{1}\hat{Z}\hat{E}\hat{+} \hat{1}\hat{4}\hat{+} \hat{\Delta}\hat{1}\hat{4}\hat{i}\hat{d}\hat{S}\hat{H}\hat{i}\hat{g}\hat{\Delta}\hat{S}\hat{T}\hat{H} \hat{E}\hat{O}\hat{E}\hat{S}\hat{+} \hat{d}\hat{g}\hat{H}\hat{i}\hat{L}\hat{E}\hat{\%}\hat{J}\hat{1}\hat{S}\hat{+}$

Mathematical solvers for scheduling problems

$E \mu \hat{u} \S e \hat{U} \S \dagger \succ \check{c} \mu \sim \wedge \ddot{E} \pm \mu / \succ \hat{z}$

Decisions	Arithmetic			Logic	Comparison	Set & List	Interval
bool	sum	sub	prod	not	==	count	start
float	min	max	abs	and	!=	contains	end
int	div	mod	sqrt	or	≥	at	length
set	log	exp	pow	xor	≤	indexOf	contains
list	cos	sin	tan	iif	>	disjoint	
interval	floor	ceil	round	array + at	<	partition	
	dist	scalar		piecewise		· % %	

Mathematical solvers for scheduling problems

$E\mu \hat{u} \hat{S}^e \hat{U} \hat{s} \hat{f} \hat{c} \hat{\mu} \hat{\sim} \hat{\wedge} \hat{E} \hat{\pm} \hat{\mu} \hat{\gg} \hat{i}$

$\text{CPAI} \hat{G} \hat{I} \hat{Z} \hat{-} \hat{G} \hat{o} \hat{E} \hat{f} \hat{i} \hat{E} \% \hat{E} \hat{S} \hat{f} \hat{i} \hat{E} \hat{f} \hat{i} \hat{d} \hat{S} \hat{H} \hat{i} \hat{g} \hat{\Delta} \hat{S} \hat{T} \hat{>} \hat{E} \hat{T} \hat{o} \hat{E} \hat{E} \hat{S} \hat{T} \hat{o} \hat{d} \hat{\Delta} \hat{f} \hat{i} \hat{T} \hat{O} \hat{S} \hat{E} \hat{H}$

```
x <- interval(Min, Max);  
y <- interval(Min, Max);  
constraint x < y;
```



Mathematical solvers for scheduling problems

$E\mu \hat{U}S^e \hat{U}S^{\dagger} \hat{c}\mu \wedge \hat{E}\pm\mu/\rangle \hat{z}$

$\text{@PAI } \hat{G}\hat{I}\hat{Z}- \Delta\text{fi}\hat{T}\hat{S}\hat{O}\hat{r} \hat{o} \hat{s}\hat{L} \cdot \hat{s}\hat{P}\hat{E}\% \hat{\%}\hat{J}\hat{g}\hat{\Delta}\hat{T}\hat{s}\hat{L}\hat{S}$

```
x <- interval(Min, Max);  
constraint length(x) == Duration;
```

Mathematical solvers for scheduling problems

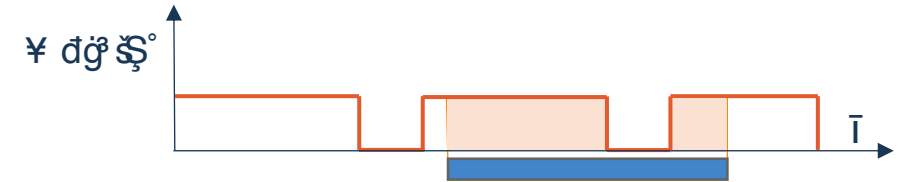
Επιλύσιμα προβλήματα

Παράδειγμα 1: Προβλήματα με διάρκεια

```
x <- interval(Min, Max);  
constraint length(x) == Duration;
```

Παράδειγμα 2: Προβλήματα με εργασία

```
x <- interval(Min, Max);  
constraint sum(x, t => Working[t]) == WorkDuration;
```



Μαθηματικά μοντέλα για την επίλυση προβλημάτων

Mathematical solvers for scheduling problems

$E_{\mu} \hat{U} S^e \hat{U} s \dagger \gg \mu \sim \wedge \hat{E} \pm \mu / \gg \hat{z}$

Ⓐ ΔĠ ĠĠ- ΔfiTŌř ō šĴ · šĤE%%ĴgΔĪšĴ

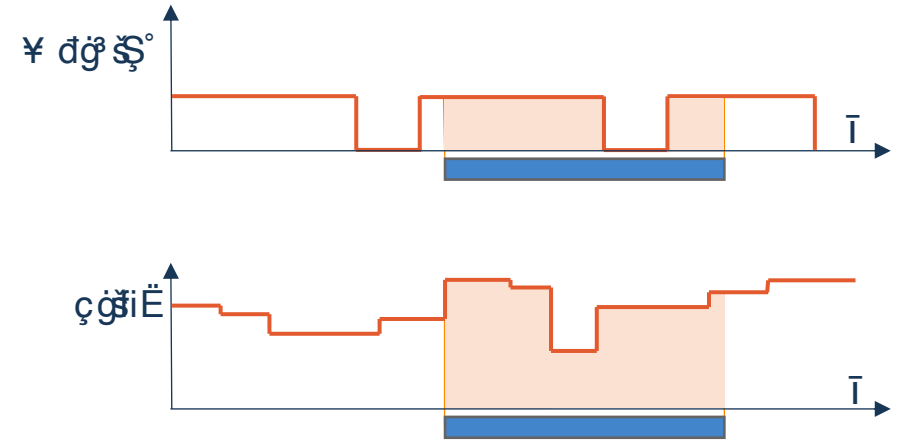
```
x <- interval(Min, Max);  
constraint length(x) == Duration;
```

Ⓐ ΔĠ ĠĠ- ΔfiTŌř ō šĴ šĴĤĤĤř · ĴšfiTšĴ

```
x <- interval(Min, Max);  
constraint sum(x, t => Working[t]) == WorkDuration;
```

Ⓐ ΔĠ ĠĠ- ΔfiTŌř ō šĴ Īš Ē%ĒĜĤ%ĤĪ ĠgšĪĒ

```
x <- interval(Min, Max);  
cost <- sum(x, t => Price[t])
```



WĒRΔĴ u ĠĪš šĤĒg %đĒĤšđĪ αĴšđđĴĴĪĒ ĒĜĜĒĤĤđĴ đĒĒĠĴĒ ĒĤĪđĒ šĴĤĒĠĴđĪ Ē

Mathematical solvers for scheduling problems

$E_{\mu} \hat{U} S^e \hat{U} S^{\dagger} \gg \check{c} \mu \sim \wedge \hat{E} \pm \mu / \gg \hat{z}$

Ⓞ_{PAI} $\hat{G} \frac{1}{2} - i \Delta^3 \hat{E} \hat{H} \hat{G} \Delta S$

```
x[i in 0...N] <- interval(Min, Max);  
minimize max[i in 0...N] end(x[i]);
```

Ⓞ_{PAI} $\hat{G} \frac{1}{2} - \bar{o} \hat{E} S \hat{L} \hat{T} \hat{E} \% \hat{H} \hat{U} \hat{i} \hat{d} \hat{d} \hat{T} \Delta \hat{g} \% \hat{S} \hat{E} \hat{H} \hat{H} \hat{f} \hat{i} \hat{d} \hat{H} \hat{r}$

```
minimize sum[i in 0...N] ( Weight[i] * max(0, end(x[i]) - DueDate[i]) );
```

Ⓞ_{PAI} $\hat{G} \frac{1}{2} - o \hat{E} \hat{T} \hat{c} \hat{g} \hat{E} \hat{H} \hat{E} \hat{S} \hat{T} \geq \Delta \hat{U} \hat{E}$

```
maximize sum[i in 0...N] ( NetCashFlow[i] / pow(1+DiscountRate, end(x[i])) );
```


Mathematical solvers for scheduling problems

$\epsilon \mu \hat{u} \hat{S} e \hat{U} \hat{s} \hat{f} \hat{c} \hat{\mu} \hat{\sim} \wedge \hat{E} \pm \mu \hat{u} \hat{u} \hat{i}$

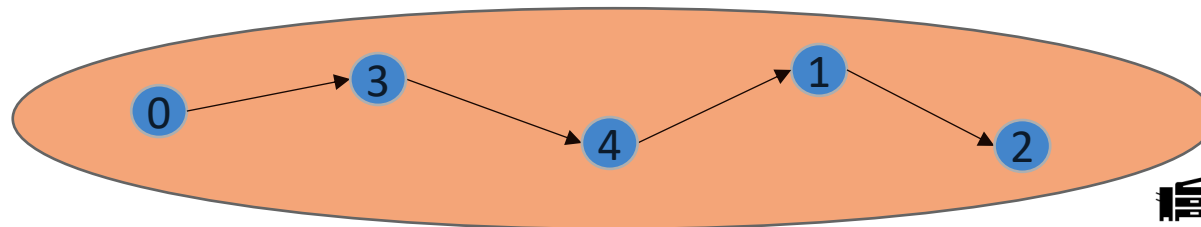
$\text{seq} \leftarrow \text{list}(N);$
 $x[i \text{ in } 0 \dots N] \leftarrow \text{interval}(\text{Min}, \text{Max});$
 $\text{constraint count}(\text{seq}) == N;$
 $\text{constraint and}(1 \dots N, i \Rightarrow x[\text{seq}[i-1]] < x[\text{seq}[i]]);$

$\text{seq} \leftarrow \text{list}(N);$

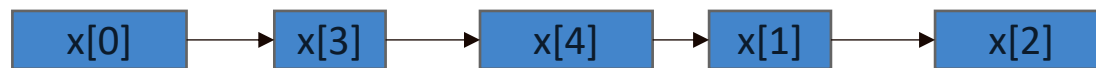
$x[i \text{ in } 0 \dots N] \leftarrow \text{interval}(\text{Min}, \text{Max});$

$\text{constraint count}(\text{seq}) == N;$

$\text{constraint and}(1 \dots N, i \Rightarrow x[\text{seq}[i-1]] < x[\text{seq}[i]]);$



$\hat{F} \hat{E} \hat{G} \hat{I} \hat{V} \hat{r} \hat{+} \hat{3} \hat{+} \hat{l} \hat{+} \hat{u} \hat{+} \hat{e}$



$\hat{o} \hat{L} \hat{E} \hat{+} \hat{d} \hat{g} \hat{J} \hat{1} \hat{\Delta} \hat{i} \hat{s} \hat{d} \hat{+} \hat{t} \hat{L} \hat{E} \hat{f} \hat{i} \hat{d} \hat{s} \hat{H} \hat{i} \hat{g} \hat{\Delta} \hat{s} \hat{+} \hat{J} \hat{H} \hat{E} \hat{H} \hat{\Delta} \hat{O} \hat{\Delta} \hat{g} \hat{s} \hat{\Delta} \hat{s} \hat{i} \hat{o} \hat{\Delta} \hat{s} \hat{\%} \hat{o} \hat{E} \hat{G} \hat{J} \hat{s} \hat{O} \hat{\Delta} \hat{s} \hat{+} \hat{t} \hat{d} \hat{\Delta} \hat{o} \hat{d} \hat{g} \hat{\Delta} \hat{1} \hat{4} \hat{E} \hat{R} \hat{G} \hat{g} \hat{E} \hat{H} \hat{s} \hat{+} \hat{H} \hat{s} \hat{E} \hat{s} \hat{H} \hat{u} \hat{s} \hat{+}$

Mathematical solvers for scheduling problems

$E\mu \hat{u} \hat{S}^e \hat{U} \hat{s} \hat{f} \hat{c} \hat{\mu} \hat{\wedge} \hat{E} \hat{\pm} \hat{\mu} \hat{\gg} \hat{i}$

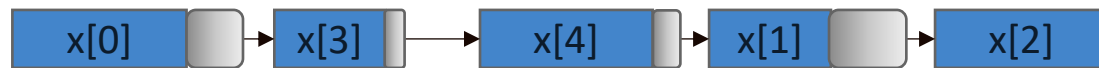
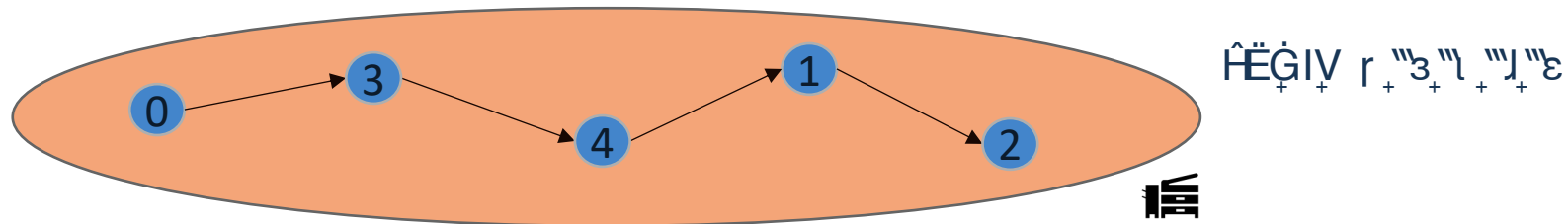
$\text{seq} \leftarrow \text{list}(N);$
 $x[i \text{ in } 0 \dots N] \leftarrow \text{interval}(\text{Min}, \text{Max});$
 $\text{constraint count}(\text{seq}) == N;$
 $\text{constraint and}(1 \dots N, i \Rightarrow \text{end}(x[\text{seq}[i-1]]) + \text{SetupTime}[\text{seq}[i-1]][\text{seq}[i]] \leq \text{start}(x[\text{seq}[i]]));$

$\text{seq} \leftarrow \text{list}(N);$

$x[i \text{ in } 0 \dots N] \leftarrow \text{interval}(\text{Min}, \text{Max});$

$\text{constraint count}(\text{seq}) == N;$

$\text{constraint and}(1 \dots N, i \Rightarrow \text{end}(x[\text{seq}[i-1]]) + \text{SetupTime}[\text{seq}[i-1]][\text{seq}[i]] \leq \text{start}(x[\text{seq}[i]]));$



$\hat{o} \hat{L} \hat{E} \hat{d} \hat{g} \hat{J} \hat{\Delta} \hat{s} \hat{d} \hat{t} \hat{L} \hat{E} \hat{f} \hat{i} \hat{d} \hat{s} \hat{H} \hat{r} \hat{g} \hat{\Delta} \hat{s} \hat{J} \hat{H} \hat{E} \hat{H} \hat{\Delta} \hat{O} \hat{\Delta} \hat{g} \hat{s} \hat{\Delta} \hat{s} \hat{j} \hat{o} \hat{\Delta} \hat{s} \hat{\%} \hat{E} \hat{G} \hat{J} \hat{s} \hat{O} \hat{\Delta} \hat{s} \hat{t} \hat{r} \hat{d} \hat{\Delta} \hat{o} \hat{d} \hat{g} \hat{\Delta} \hat{1} \hat{4} \hat{E} \hat{R} \hat{G} \hat{g} \hat{E} \hat{H} \hat{s} \hat{d} \hat{s} \hat{H} \hat{s} \hat{E} \hat{s} \hat{H} \hat{u} \hat{s}$

Mathematical solvers for scheduling problems

$E_{\mu} \hat{U} \check{S} e \check{U} \check{s} \check{f} \check{c} \check{\mu} \sim \wedge \check{E} \pm \mu / \check{r} \check{i}$

$\textcircled{P} \Delta \hat{G} \check{I} \check{Z} - \% \hat{H} \hat{J} \check{S} \check{f} \check{i} \check{T} \check{S} \check{O} \check{E} \check{g} \check{E} \check{H} \hat{J} \check{g} \check{i} \check{E} \check{i} \Delta \check{f} \check{i} \check{L} \check{S} \check{E} \check{o} \check{s} \check{L} \hat{H} \check{E} \check{G} \hat{J} \check{E} \check{S} \check{f} \check{i} \check{E} \check{=} \% \check{E} \check{G} \check{E} \check{S} \% \check{E} \check{S} \check{T} \hat{H} \check{E} \check{T} \hat{J} \hat{G} \check{T} \check{S} \check{E} \hat{H}$

```
seq <- list(N);
```

```
x[i in 0...N] <- interval(Min, Max);
```

```
constraint count(seq) == N;
```

```
constraint and(1...N, i => end(x[seq[i-1]]) + SetupTime[seq[i-1]][seq[i]] <= start(x[seq[i]]));
```

$\textcircled{P} \Delta \hat{G} \check{I} \check{Z} - \hat{H} \check{E} \check{T} \hat{J} \hat{G} \check{f} \check{i} \check{d} \hat{H} \check{i} \hat{H}$

```
minimize sum(1...N, i => SetupCost[seq[i-1]][seq[i]]);
```

Mathematical solvers for scheduling problems

$E\mu \hat{U}\$e \hat{U}\$ \check{c}\mu \wedge \hat{E}\pm\mu/\gg \hat{z}$

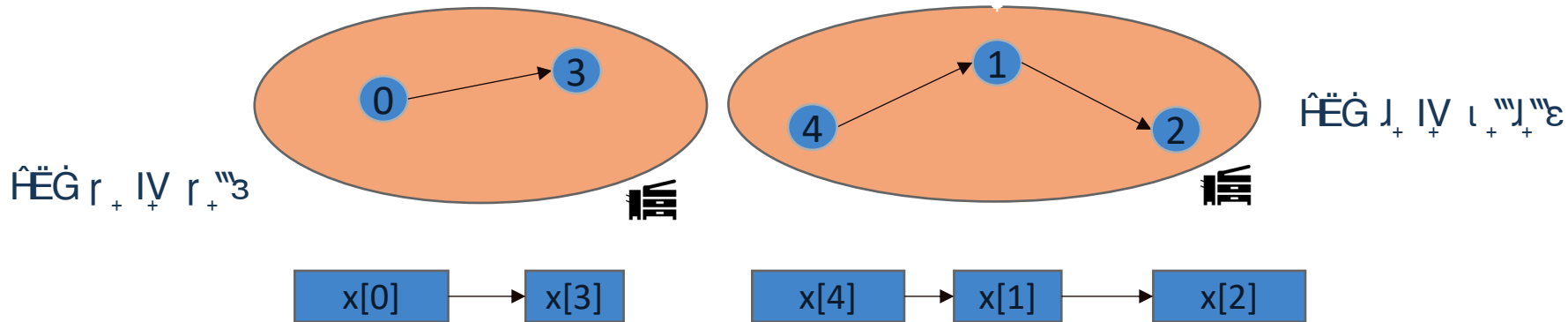
$\text{seq}[j \text{ in } 0..M] \leftarrow \text{list}(N);$

$x[i \text{ in } 0..N] \leftarrow \text{interval}(\text{Min}, \text{Max});$

$\text{constraint } \text{partition}(\text{seq});$

$\text{for } [j \text{ in } 0..M] \text{ constraint } \text{and}(1..\text{count}(\text{seq}[j]), i \Rightarrow x[\text{seq}[j][i-1]] < x[\text{seq}[j][i]]);$

$\text{for } [j \text{ in } 0..M] \text{ constraint } \text{and}(1..\text{count}(\text{seq}[j]), i \Rightarrow x[\text{seq}[j][i-1]] < x[\text{seq}[j][i]]);$



$\hat{o}\hat{L}\hat{E} \text{'dg} \hat{J} \hat{1}\hat{\Delta}\hat{s}\hat{d} \hat{d}_+ \hat{t}\hat{L}\hat{E} \hat{f}\hat{i}\hat{d}\hat{s}\hat{H}\hat{r}\hat{g}\hat{\Delta}\hat{s}\hat{I} \hat{J}\hat{H}\hat{E}\hat{H}\hat{\Delta} \hat{O}\hat{\Delta}\hat{g}\hat{s}\hat{\Delta}\hat{s}\hat{j} \hat{o}\hat{\Delta}\hat{s}\hat{\%}_+ \hat{E}\hat{G}\hat{J} \hat{s}\hat{O}\hat{1}\hat{z}\hat{s}\hat{I} \hat{I}\hat{d} \hat{\Delta}\hat{o}\hat{d}\hat{g}\hat{\Delta}\hat{1}\hat{4}\hat{E}\hat{R}\hat{G}\hat{g}\hat{E}\hat{H}\hat{s}\hat{d}\hat{s} \hat{-} \hat{H}\hat{s}\hat{E} \hat{s}\hat{H}\hat{u} \hat{s}_+$

Mathematical solvers for scheduling problems

$E_{\mu} \hat{U} \hat{S}^e \hat{U} \hat{s} \hat{t} \hat{c} \hat{\mu} \sim \wedge \hat{E} \pm \mu / \gg \hat{z}$

`@Pai G1Z- %sHJŠfiTŠÖĚ ġĚĤĴġiĚ ĩ ΔfiLŠĚ ΔfiΔTšĚ`

```
seq[j in 0..M] <- list(N);
```

```
x[i in 0..N] <- interval(Min, Max);
```

```
constraint partition(seq);
```

```
for [j in 0..M] constraint and(1...count(seq[j]), i => x[seq[j][i-1]] < x[seq[j][i]]);
```

`@Pai G1Z- ġĚĤĴġiĚ %ĚĚŠ%ĚŠĪ ·ĚΔĪĴġĚĤ`

```
constraint contains(seq[0], 3); + 6đi ĠĴĤġ ĩ ΔfiLŠĚ
```

```
constraint !contains(seq[0], 2); + Zšfiđi ĠΔĪš 1Z ĩ ΔfiLŠĚ
```

```
constraint contains(seq[0], 1) <= !contains(seq[1], 4) ; + <ĚĚŠ%ĚŠfiĪ fiđŠĤġΔŠĤĤ
```

Mathematical solvers for scheduling problems

$E_{\mu} \hat{U} \hat{S}^e \hat{U} \hat{S} \hat{f} \hat{c} \hat{\mu} \sim \wedge \hat{E} \pm \mu / \gg \hat{z}$

$\text{seq}[j \text{ in } 0..M] \leftarrow \text{list}(N);$

$x[i \text{ in } 0..N] \leftarrow \text{interval}(\text{Min}, \text{Max});$

$\text{constraint } \text{partition}(\text{seq});$

$\text{for } [j \text{ in } 0..M] \text{ constraint } \text{and}(1..count(\text{seq}[j]), i \Rightarrow x[\text{seq}[j][i-1]] < x[\text{seq}[j][i]]);$

$m[i \text{ in } 0..N] \leftarrow \text{find}(\text{seq}, i);$ // n $\Delta \text{fi} \hat{L} \hat{S} \hat{E} \hat{d} \hat{t} \hat{\Delta} \hat{P} \hat{s} \hat{E} \hat{Z} \hat{I} \hat{E} \hat{S} \hat{t} \hat{d} \hat{t} \hat{L} \hat{E} \hat{G} \hat{\Delta} \hat{g} \hat{t} \hat{s} \hat{s} \hat{s} \hat{E} \hat{t} \hat{S} \hat{H} \hat{t} \hat{d}$

$\text{for } [i \text{ in } 0..N] \{$

$\text{constraint } \text{length}(x[i]) == \text{Duration}[i][m[i]];$ + n $\Delta \text{fi} \hat{L} \hat{S} \hat{E} \hat{d} \hat{t} \hat{\Delta} \hat{P} \hat{s} \hat{E} \hat{Z} \hat{I} \hat{E} \hat{S} \hat{t} \hat{d} \hat{t} \hat{L} \hat{E} \hat{G} \hat{\Delta} \hat{g} \hat{t} \hat{s} \hat{s} \hat{s} \hat{E} \hat{t} \hat{S} \hat{H} \hat{t} \hat{d}$

$\text{constraint } \text{start}(x[i]) \geq \text{AvailableTime}[m[i]];$ + n $\Delta \text{fi} \hat{L} \hat{S} \hat{E} \hat{H} \hat{t} \hat{\Delta} \hat{g} \hat{t} \hat{t} \hat{s} \hat{E}$

$\}$

Mathematical solvers for scheduling problems

$E\mu \hat{U}S'e \hat{U}S\ddagger \succ\check{c}\mu \sim \wedge \hat{E}\pm\mu/\succ \hat{z}$

$\textcircled{P}\Delta \hat{G}\hat{Z}-fi\hat{J}\hat{I} \hat{J} \hat{1}\Delta \hat{S}\hat{O}\hat{E} \hat{g}\hat{E}\hat{H}\hat{t}\hat{J}\hat{g}\hat{i}\hat{E}$

$\bar{\tau} \Delta S \bar{\tau} \bar{s} \hat{E} \hat{r} \hat{r} \hat{L} \hat{E} \hat{H} \hat{I} \hat{d} \hat{r} \hat{r} \hat{L} \hat{E} \hat{o} \hat{E} \hat{s} \hat{L} \hat{r} \hat{H} \hat{d} \hat{r} \hat{r} \hat{L} \hat{E} \hat{r} \hat{\Delta} \hat{P} \hat{H} \hat{g} \hat{J} \hat{S} \hat{S} \hat{S} \hat{o} \hat{d} \hat{S} \hat{r} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{t} \hat{J} \hat{g} \hat{i} \hat{E} \hat{i} \hat{J} \hat{H} \hat{r} \succ \hat{E} \hat{1} \hat{4} \hat{H} \hat{r} \hat{L} \hat{\Delta} \hat{S} \hat{r} \hat{L} \hat{E}$
 $fi \hat{\Delta} \hat{G} \hat{\Delta} \hat{r} \hat{s} \hat{r} \hat{d} \hat{r} \hat{r} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{t} \hat{J} \hat{g} \hat{i} \hat{E}$

```
x[i in 0..N] <- interval(Min, Max);
```

Mathematical solvers for scheduling problems

$E\mu \hat{U}S'e \hat{U}S\ddagger \succ \check{c}\mu \sim \wedge \hat{E}\pm\mu/\succ \hat{z}$

$\textcircled{P}\Delta \hat{G}\hat{L}\hat{Z}-fi\hat{J}\hat{I} \hat{J} \hat{1}\hat{\Delta}\hat{T}\hat{S}\hat{O}\hat{E} \hat{g}\hat{E}\hat{H}\hat{d}\hat{J}\hat{g}\hat{i}\hat{E}$

$\hat{T} \hat{\Delta}\hat{S}\hat{r} \hat{T}\hat{s} \hat{E} \hat{r}\hat{Y}\hat{L}\hat{E}\hat{H}\hat{U}\hat{I} \hat{d} \hat{T}\hat{L}\hat{E} \hat{o} \hat{E}\hat{s} \hat{L}\hat{T}\hat{H}\hat{d} \hat{T}\hat{L}\hat{E} \hat{T}\hat{\Delta}\hat{P} \hat{H}\hat{g}\hat{J}\hat{S}\hat{S}\hat{S} \hat{d}\hat{S} \hat{T}\hat{L}\hat{E} \hat{g}\hat{E}\hat{H}\hat{d}\hat{J}\hat{g}\hat{i}\hat{E} \hat{I} \hat{J}\hat{H}\hat{r} \succ \hat{E} \hat{H}\hat{H}\hat{T}\hat{L}\hat{\Delta}\hat{S}$
 $\hat{T}\hat{L}\hat{E} \hat{fi}\hat{\Delta}\hat{G}\hat{\Delta}\hat{fi}\hat{s}\hat{r} \hat{d} \hat{T}\hat{L}\hat{E} \hat{g}\hat{E}\hat{H}\hat{d}\hat{J}\hat{g}\hat{i}\hat{E}$

```
x[i in 0..N] <- interval(Min, Max);  
constraint and(0..Horizon,  
               t =>  
               ...);
```

Mathematical solvers for scheduling problems

$E\mu \hat{u} \hat{S}^e \hat{U} \hat{s} \hat{f} \hat{c} \hat{\mu} \hat{\sim} \hat{\wedge} \hat{E} \hat{\pm} \hat{\mu} \hat{\gg} \hat{i}$

$\text{CPAI} \hat{G} \hat{I} \hat{Z} \hat{-} \hat{f} \hat{i} \hat{J} \hat{I} \hat{J} \hat{1} \hat{\Delta} \hat{T} \hat{S} \hat{O} \hat{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E}$

$\hat{T} \hat{\Delta} \hat{S} \hat{r} \hat{T} \hat{s} \hat{E} \hat{\wedge} \hat{T} \hat{L} \hat{E} \hat{H} \hat{U} \hat{I} \hat{d} \hat{T} \hat{L} \hat{E} \hat{o} \hat{E} \hat{s} \hat{L} \hat{T} \hat{H} \hat{d} \hat{T} \hat{L} \hat{E} \hat{T} \hat{\Delta} \hat{P} \hat{H} \hat{g} \hat{J} \hat{S} \hat{S} \hat{S} \hat{S} \hat{d} \hat{S} \hat{T} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{I} \hat{J} \hat{H} \hat{T} \hat{E} \hat{1} \hat{Z} \hat{H} \hat{T} \hat{L} \hat{\Delta} \hat{S}$
 $\hat{T} \hat{L} \hat{E} \hat{f} \hat{i} \hat{\Delta} \hat{G} \hat{\Delta} \hat{f} \hat{i} \hat{s} \hat{r} \hat{d} \hat{T} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E}$

```
x[i in 0..N] <- interval(Min, Max);  
constraint and(0...Horizon,  
              t =>  
              sum[i in 0..N](Weight[i] ...
```

Mathematical solvers for scheduling problems

$E\mu \hat{u} \hat{S}^e \hat{U} \hat{s} \hat{t} \hat{c} \hat{\mu} \sim \wedge \hat{E} \pm \mu / \gg \hat{z}$

$\hat{C} \hat{P} \hat{A} \hat{I} \hat{G} \hat{I} \hat{Z} - \hat{f} \hat{i} \hat{J} \hat{I} \hat{J} \hat{1} \hat{\Delta} \hat{T} \hat{S} \hat{O} \hat{E} \hat{g} \hat{E} \hat{H} \hat{t} \hat{J} \hat{g} \hat{i} \hat{E}$

$\hat{T} \hat{\Delta} \hat{S} \hat{r} \hat{T} \hat{s} \hat{E} \hat{r} \hat{Y} \hat{L} \hat{E} \hat{H} \hat{U} \hat{I} \hat{d} \hat{T} \hat{L} \hat{E} \hat{o} \hat{E} \hat{s} \hat{L} \hat{T} \hat{H} \hat{d} \hat{T} \hat{L} \hat{E} \hat{T} \hat{\Delta} \hat{P} \hat{H} \hat{g} \hat{J} \hat{S} \hat{S} \hat{S} \hat{S} \hat{d} \hat{S} \hat{T} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{t} \hat{J} \hat{g} \hat{i} \hat{E} \hat{I} \hat{J} \hat{H} \hat{T} \hat{E} \hat{H} \hat{H} \hat{T} \hat{L} \hat{\Delta} \hat{S}$
 $\hat{T} \hat{L} \hat{E} \hat{f} \hat{i} \hat{\Delta} \hat{G} \hat{\Delta} \hat{f} \hat{i} \hat{s} \hat{r} \hat{d} \hat{T} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{t} \hat{J} \hat{g} \hat{i} \hat{E}$

```
x[i in 0..N] <- interval(Min, Max);  
constraint and(0..Horizon,  
  t =>  
    sum[i in 0..N](Weight[i] * contains(x[i], t)) ...
```

Mathematical solvers for scheduling problems

$E\mu \hat{u} \hat{S}^e \hat{U} \hat{s} \hat{f} \hat{c} \hat{\mu} \sim \wedge \hat{E} \pm \mu / \gg \hat{i}$

$\hat{C} \hat{P} \hat{A} \hat{I} \hat{G} \hat{I} \hat{Z} - \hat{f} \hat{i} \hat{J} \hat{I} \hat{J} \hat{1} \hat{A} \hat{T} \hat{S} \hat{O} \hat{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E}$

$\hat{T} \hat{\Delta} \hat{S} \hat{r} \hat{T} \hat{s} \hat{E} \hat{r} \hat{Y} \hat{L} \hat{E} \hat{H} \hat{U} \hat{I} \hat{d} \hat{T} \hat{L} \hat{E} \hat{o} \hat{E} \hat{s} \hat{L} \hat{T} \hat{H} \hat{d} \hat{T} \hat{L} \hat{E} \hat{T} \hat{\Delta} \hat{P} \hat{H} \hat{g} \hat{J} \hat{S} \hat{S} \hat{S} \hat{o} \hat{d} \hat{S} \hat{T} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{i} \hat{J} \hat{H} \hat{T} \hat{E} \hat{1} \hat{Z} \hat{H} \hat{H} \hat{T} \hat{L} \hat{\Delta} \hat{S}$
 $\hat{T} \hat{L} \hat{E} \hat{f} \hat{i} \hat{\Delta} \hat{G} \hat{\Delta} \hat{f} \hat{i} \hat{s} \hat{r} \hat{d} \hat{T} \hat{L} \hat{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E}$

```
x[i in 0..N] <- interval(Min, Max);  
constraint and(0...Horizon,  
               t =>  
               sum[i in 0...N](Weight[i] * contains(x[i], t)) <= Capacity);
```

$\hat{o} \hat{L} \hat{E} \hat{f} \hat{i} \hat{d} \hat{S} \hat{H} \hat{i} \hat{g} \hat{\Delta} \hat{S} \hat{T} \hat{s} \hat{H} \hat{o} \hat{g} \hat{a} \hat{T} \hat{E} \hat{S} \hat{s} \hat{s} \hat{T} \hat{E} \hat{S} \hat{T} \hat{s} \hat{T} \hat{S} - \hat{W} \hat{E} \hat{R} \hat{\Delta} \hat{1} \hat{4} \hat{u} \hat{G} \hat{i} \hat{s} \hat{s} \hat{E} \hat{g} \% \hat{d} \hat{E} \hat{H} \hat{S} \hat{d} \hat{T} \hat{J} \hat{S} \hat{g} \hat{d} \hat{1} \hat{4} \hat{L} \hat{E} \hat{1} \hat{d} \hat{G} \hat{d} \hat{S} \hat{T}$

Mathematical solvers for scheduling problems

$E\mu \hat{u}S'e \hat{U}S\ddagger \succ \check{c}\mu \sim \wedge \hat{E}\pm\mu/\succ \hat{z}$

$\textcircled{P}\Delta \hat{G}\frac{1}{2}-fi\hat{J}\hat{I} \hat{J} \frac{1}{2}\Delta\hat{S}\hat{O}\hat{E} \hat{g}\hat{E}\hat{H}\hat{d}\hat{J}\hat{g}\hat{i}\hat{E}$

$\hat{o}\hat{L}\hat{E}\hat{T}\hat{E}\hat{I} \hat{G}\hat{d}\hat{g}\frac{1}{4}\hat{H}\hat{i}\hat{d}\hat{G}\hat{E}\hat{f}\hat{i}\hat{\Delta}\hat{S} \succ \hat{E} \hat{\Delta} \hat{O}\hat{\Delta}\hat{g}\hat{\Delta} \frac{1}{2}\hat{g}\hat{\Delta}\hat{S}^\circ \hat{E} \hat{d}\hat{g}\hat{\Delta}\hat{S} \hat{S}\hat{S}\hat{T}\hat{E}\hat{g}\hat{O}\hat{\Delta}\frac{1}{4}\hat{O}\hat{\Delta}\hat{g}\hat{\Delta} \frac{1}{2}$

```
x[i in 0..N] <- interval(Min, Max);  
constraint and(0...makespan,  
               t =>  
               sum[i in 0..N](Weight[i] * contains(x[i], t)) <= Capacity);
```

$\hat{o}\hat{L}\hat{E}\hat{f}\hat{i}\hat{d}\hat{S}\hat{H}\hat{i}\hat{g}\hat{\Delta}\hat{S}\hat{T} \hat{S}\hat{H}\hat{o} \hat{g}\hat{H}\hat{T}\hat{E}\hat{S} \hat{S} \hat{S}\hat{S}\hat{T}\hat{E}\hat{S}\hat{T}\hat{S}\hat{T} \hat{S}\hat{T} \hat{W}\hat{E}\hat{R}\hat{\Delta}\frac{1}{4} \hat{u} \hat{G}\hat{i}\hat{S} \hat{S}\hat{E}\hat{g}\% \hat{d}\hat{E}\hat{H}\hat{S}\hat{d}\hat{T} \hat{J} \hat{S}\hat{g}\hat{d} \frac{1}{4}\hat{L}\hat{E} \frac{1}{2}\hat{d}\hat{G}\hat{d}\hat{S} \hat{T}$

Mathematical solvers for scheduling problems

$E\mu \hat{U}S'e \hat{U}S\ddagger \succ\check{c}\mu \sim \wedge \hat{E}\pm\mu/\succ \hat{z}$

$\textcircled{P}\Delta \hat{G}\hat{Z}-fi\hat{J}\hat{I} \hat{J} \hat{1}\Delta\hat{T}\hat{S}\hat{O}\hat{E} \hat{g}\hat{E}\hat{H}\hat{d}\hat{J}\hat{g}\hat{i}\hat{E}$

$\hat{o}\hat{L}\hat{E} fi\Delta\hat{G}\Delta fi\hat{s}\hat{r} \hat{i} \Delta\hat{r} \succ \hat{E} \hat{T}\hat{s} \hat{E} \hat{=} \hat{E}\hat{G}\hat{E}\hat{S}\hat{E}\hat{S}\hat{T}$

```
x[i in 0..N] <- interval(Min, Max);  
constraint and(0..makespan,  
               t =>  
               sum[i in 0..N](Weight[i] * contains(x[i], t)) <= Capacity[t]);
```

$\hat{o}\hat{L}\hat{E} fi\hat{d}\hat{S}\hat{H}\hat{i}\hat{g}\hat{\Delta}\hat{S}\hat{T} \hat{s}\hat{H}\hat{o} \hat{g}\hat{s}\hat{T}\hat{E}\hat{S} \hat{s}\hat{s}\hat{T}\hat{E}\hat{S}\hat{T}\hat{s}\hat{T}\hat{S}- \hat{W}\hat{E}\hat{R}\hat{\Delta}\hat{1}\hat{4} \hat{u} \hat{G}\hat{i}\hat{s} \hat{s}\hat{E}\hat{g}\hat{E}\hat{H}\hat{S}\hat{d}\hat{T} \hat{J} \hat{S}\hat{g}\hat{d} \hat{1}\hat{4}\hat{L}\hat{E} \hat{1}\hat{d}\hat{G}\hat{d}\hat{S} \hat{7}$

Mathematical solvers for scheduling problems

$E\mu \hat{u} S^e \hat{U} s \dagger \check{c} \mu \sim \wedge \ddot{E} \pm \mu / \gg \dot{\iota}$

$\textcircled{P} \Delta \hat{G} \ddot{L} \text{-} \text{fi} \hat{J} \hat{I} \hat{J} \hat{1} \Delta \hat{S} \ddot{O} \ddot{E} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \ddot{E}$

$\ddot{o} \ddot{L} \ddot{E} \hat{\tau} \Delta \hat{H} \hat{P} \hat{H} \hat{i} \hat{d} \hat{G} \ddot{E} \hat{I} \Delta \hat{r} \gg \ddot{E} \Delta \ddot{O} \Delta \hat{g} \hat{s} \Delta \hat{1} \ddot{L} \hat{H} \ddot{E} \hat{\tau}$

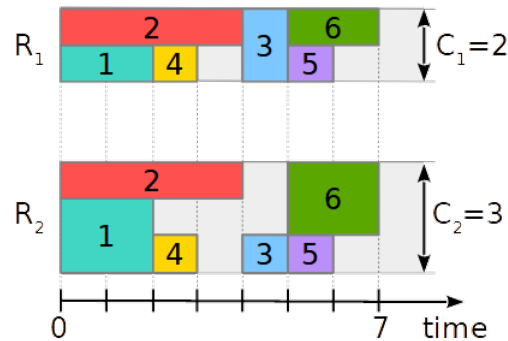
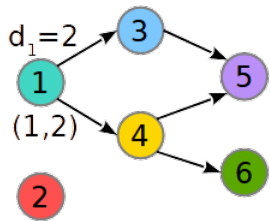
```
x[i in 0..N] <- interval(Min, Max);  
constraint and(0..makespan,  
              t =>  
              sum(taskset, i => (Weight[i] * contains(x[i], t)) <= Capacity[t]));
```

$\ddot{o} \ddot{L} \ddot{E} \hat{f} \hat{i} \hat{d} \hat{S} \hat{H} \hat{i} \hat{g} \Delta \hat{S} \hat{\tau} \hat{s} \hat{H} \hat{o} \hat{g} \hat{\tau} \hat{E} \hat{S} \hat{s} \hat{s} \hat{\tau} \hat{E} \hat{S} \hat{\tau} \hat{s} \hat{s} \hat{\tau} \hat{W} \hat{E} \hat{R} \hat{\Delta} \hat{1} \hat{4} \hat{u} \hat{G} \hat{\tau} \hat{s} \hat{s} \hat{E} \hat{g} \% \hat{d} \hat{E} \hat{H} \hat{S} \hat{d} \hat{\tau} \hat{J} \hat{S} \hat{g} \hat{d} \hat{1} \hat{4} \hat{L} \hat{E} \hat{1} \hat{d} \hat{G} \hat{d} \hat{S} \hat{\tau}$

Mathematical solvers for scheduling problems

$E \mu \hat{U} \hat{S} e \hat{U} \hat{s} \hat{t} \hat{c} \hat{\mu} \hat{r} \hat{\wedge} \hat{E} \hat{\pm} \hat{\mu} \hat{r} \hat{c} \hat{i}$

$\forall \hat{g} \hat{\Delta} \hat{G} \hat{J} \hat{G} \hat{6} \hat{d} \hat{l} \hat{G} \hat{I} \hat{E} \hat{i} \hat{c} \hat{i} \hat{d} \hat{\%} \hat{E} \hat{1} \hat{4} \hat{d} \hat{g} \hat{l} \hat{E} \hat{e} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{6} \hat{d} \hat{S} \hat{H} \hat{g} \hat{\Delta} \hat{S} \hat{E} \hat{\%} \hat{c} \hat{g} \hat{d} \hat{1} \hat{E} \hat{f} \hat{i} \hat{r} \hat{i} \hat{f} \hat{i} \hat{L} \hat{E} \hat{\%} \hat{J} \hat{S} \hat{\circ} \hat{c} \hat{g} \hat{d} \hat{1} \hat{E} \hat{i} \hat{e} \hat{6} \hat{c} \hat{i} \hat{c}$



\hat{W} \hat{i} $\hat{f} \hat{i} \hat{L} \hat{E} \hat{\%} \hat{J} \hat{L} \hat{d} \hat{g} \hat{s} \hat{d} \hat{S}$
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 $6 \hat{c} \hat{g} -$ $6 \hat{\Delta} \hat{G} \hat{\Delta} \hat{i} \hat{s} \hat{r} \hat{d} \hat{r} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{g}$
 $\hat{t} \hat{i} \hat{@} \hat{s} \hat{g} -$ $\hat{e} \hat{J} \hat{\Delta} \hat{S} \hat{i} \hat{s} \hat{r} \hat{d} \hat{r} \hat{g} \hat{E} \hat{H} \hat{d} \hat{J} \hat{g} \hat{i} \hat{E} \hat{g} \hat{J} \hat{H} \hat{E} \hat{\%} \hat{r} \hat{i} \hat{\Delta} \hat{P} \hat{s}$

 $\hat{i} \hat{\Delta} \hat{P} \hat{s} -$ $\hat{Z} \hat{S} \hat{T} \hat{E} \hat{g} \hat{\Delta} \hat{g} \hat{E} \hat{G} \hat{E} \hat{H} \hat{E} \hat{S} \hat{T} \hat{S} \hat{\circ} \hat{i} \hat{\Delta} \hat{P} \hat{s}$

```

function model() {
    task[i in 0...n] <- interval(0, H);
    for [i in 0...n] constraint length(task[i]) == DUR[i];
    for [i in 0...n][j in 0...NSUCC[i]] constraint task[i] < task[SUCC[i][j]];
    makespan <- max[i in 0...n](end(task[i]));
    for [r in 0...m]
        constraint and(0...makespan, t => sum[i in 0...n](USE[i][r] * contains(task[i],t)) <= CAP[r]);
    minimize makespan;
}
    
```

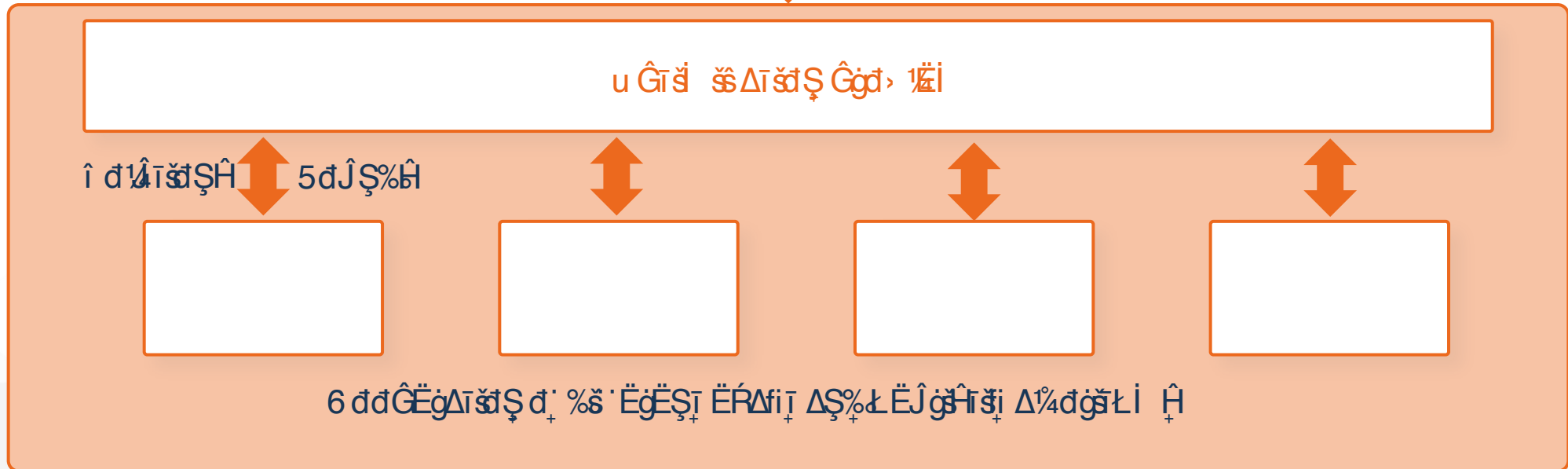
Mathematical solvers for scheduling problems

Επιλύσιμα προβλήματα

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PROVEN PERFORMANCE

Check our benchmarks

We maintain benchmarks with the best solvers in the competition. Be sure to use the most powerful optimization technology to solve your problems.

[More benchmarks >](#)

Traveling Salesman Problem (TSP)

vehicle routing

Capacitated Vehicle Routing Problem (CVRP)

vehicle routing

K-Means Clustering Problem (MSSC)

clustering

Flexible Job Shop Scheduling Problem (FJSP)

production scheduling

Simple Assembly Line Balancing Problem (SALBP)

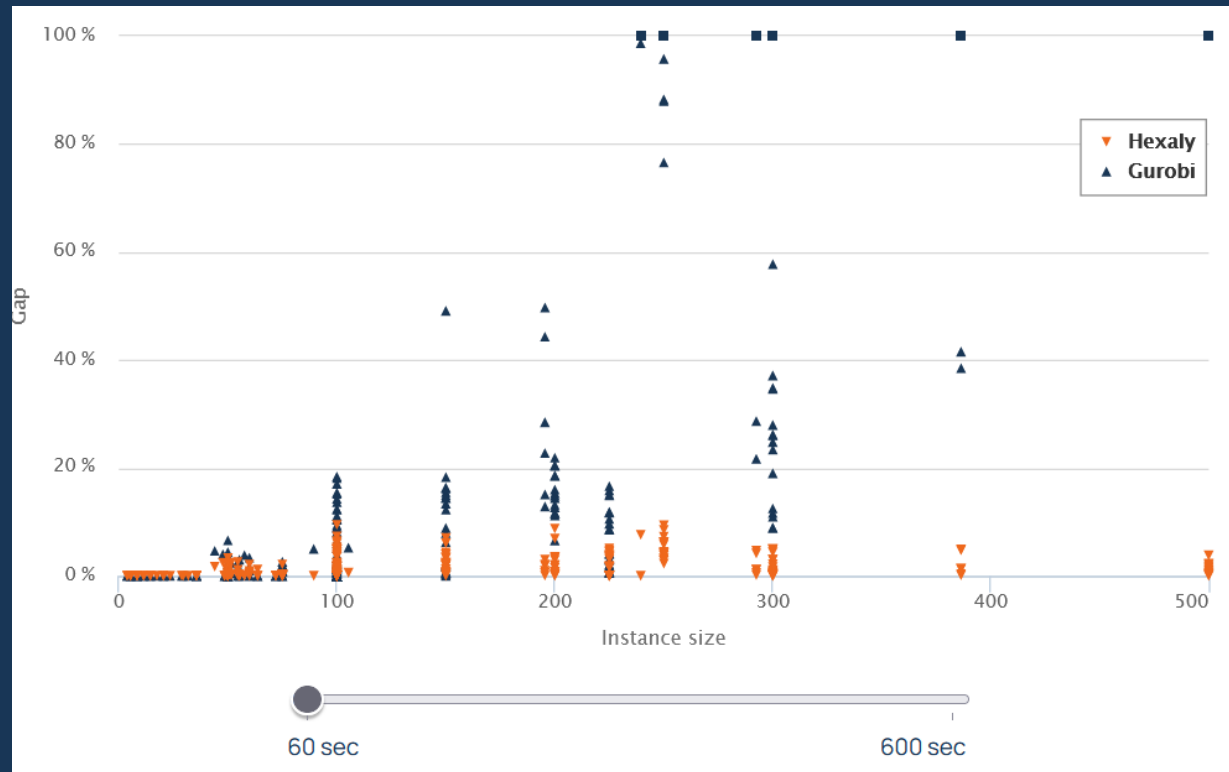
production scheduling

Bin Packing Problem

packing

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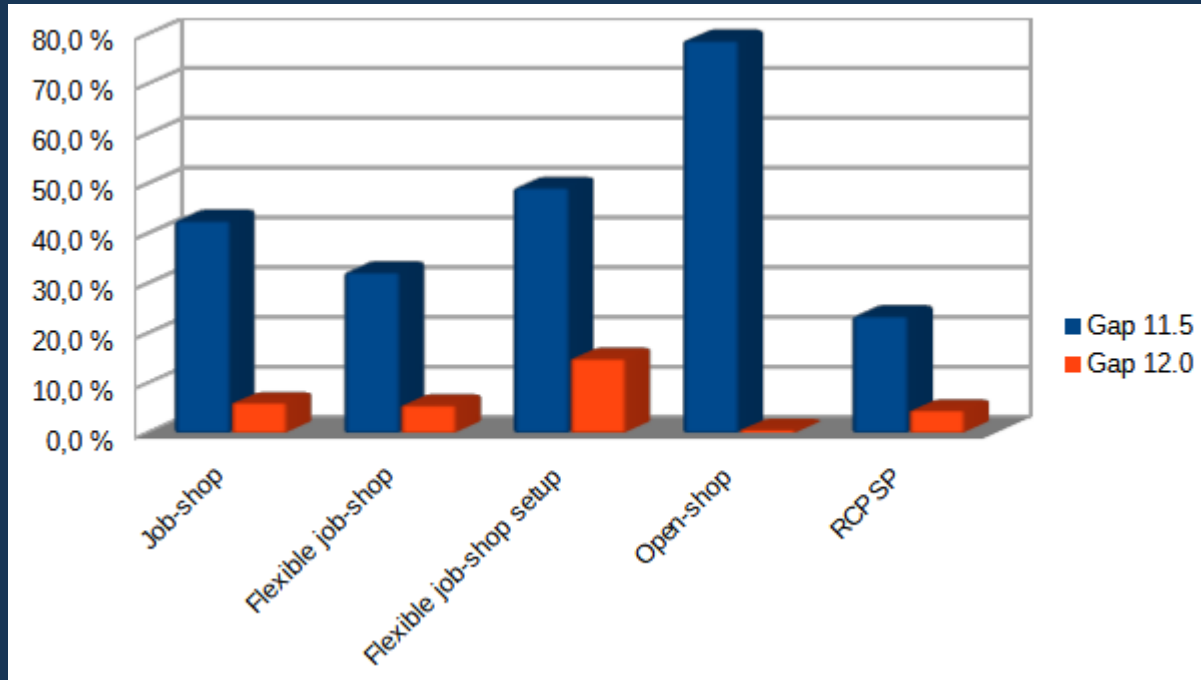
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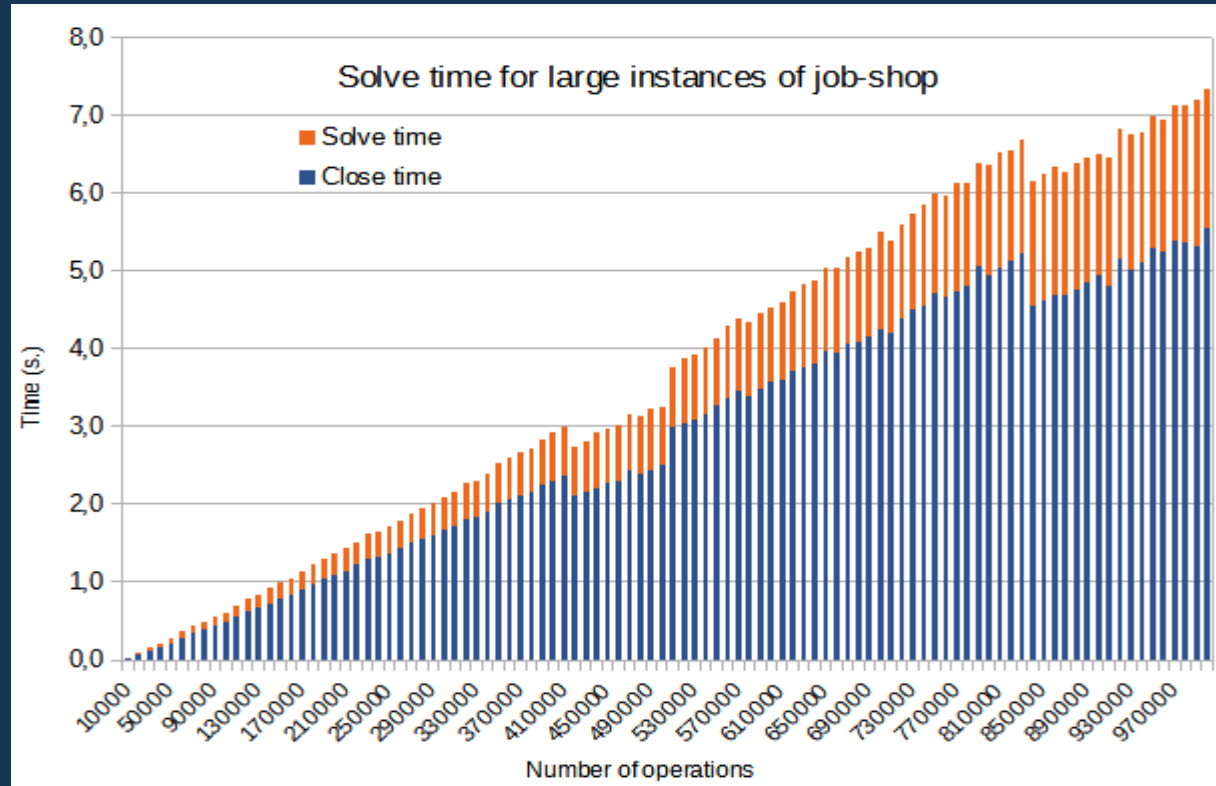
production scheduling

Simple Assembly Line Balancing Problem (SALBP)

production scheduling

Bin Packing Problem

packing



Mathematical solvers for scheduling problems

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