secret santa:

	v	t	u
v		x_0	x_1
t	x_2		x_3
u	x_4	x_5	

$$p(x_0 + x_1 - 1)^2 + p(x_2 + x_3 - 1)^2 +$$
$$p(x_4 + x_5 - 1)^2 + p(x_2 + x_4 - 1)^2 +$$
$$p(x_0 + x_5 - 1)^2 + p(x_1 + x_3 - 1)^2$$

factor out p?

try with different p?

$$= (x_i + x_j - 1)(x_i + x_j - 1)$$

$$-x_i - x_j + 1$$
$$-x_j \quad x_j^2 \quad x_i x_j$$
$$-x_i \quad x_i^2 \quad x_i x_j$$

$$x_i^2 + x_j^2 + 2x_i x_j - 2x_i - 2x_j + 1 \quad (p = 1)$$

qio notes

Term(w=5, indeces=[1,2,3])
↑ weight

variables : x, y, z, q

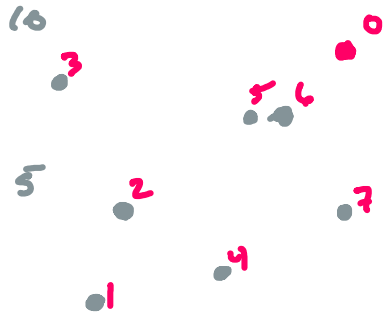
expression	w	indeces
3	3	[]
$5x^2$	5	[0,0]
3xy	3	[0,1]
-7zq	-7	[2,3]

$3x_1x_5x_7 + 3x_1x_9x_5 - 3x_7x_5x_1$

simplify logic steps:

- eliminate duplicate indeces
- sort all indeces in asc order
- ~~remove identical terms of opp signs~~
- combine like terms this does ↑
- check glow for other optimizations

curp



	loc	q
dupl:	9,9	
	1,1	1
	2,4	1
	0,8	1
	5,2	1

0 0 5 10

$i,j \in 0 \cdots \#\text{cust}-1$ 6,7   1

$k \in 0 \cdots \#\text{veh}-1$ 7,7   1

q = capacity   9,4   1

to $\min \sum_i \sum_j \sum_k c_{ijk} x_{ijk}$

c_{ijk} = cost (euclidian dist $i-j$)

$x_{ijk} = 1 \iff$ vehicle k goes from i to j

p1 $\forall_i \sum_j \sum_k x_{ijk} = 1$ → $p_0 x_{iik}$ $\forall k$
→ $p_1 (x_{ij0} - x_{ij1} - \cdots x_{ijk} - 1)^2$ $\forall_i, \forall_j$ $i \neq j$

p2 $\forall_k \sum_j x_{0jk} = 1$ → $p_2 (x_{01k} - x_{02k} - \cdots x_{0jk} - 1)^2$ each k

p3 $\forall_j \forall_k \sum_i x_{ijk} - \sum_i x_{jik} = 0$ need this one?

p4 $\forall_k \sum_i q_i \sum_j x_{ijk} \leq Q$ → $p_4 (q_1 x_{11k} + q_2 x_{21k} + \cdots + q_n x_{n1k} + q_1 x_{12k} + \cdots + q_n x_{n2k} + \cdots + q_n x_{nnk} - Q)$

don't square
foreach k, iter $i \neq j$

iterations

vehicles	q	Q	
2	1 each	4	get penalties right

4 | 1 const | 2
2 | var | 4
scale up... read files from site...

index i, j, k (4 cust 2 veh)

j \ i	0	1	2	3
0	0	1	3	5	7
1	8	9	11	13	15
2	16	17	19	21	23
3	24	25	27	29	31

$2i + 2 \cdot 4j + k = s$

$j = s \% (2 \cdot 4)$

$i = (s - (2 \cdot 4)j) \% 2$

$k = s - 2i - 8j$

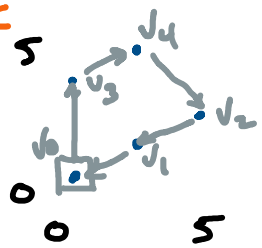
---

cvrp = tsp + knapsack

tsp = hc + cost between nodes

$x_{vj} = 1 \iff$ Vertex v step j

hc



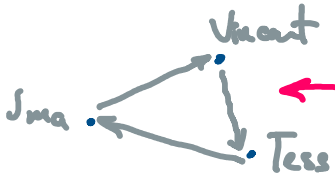
$n = 5$

$x_{00} = 1$ ← fixed?! (depot)
$x_{31} = 1$
$x_{42} = 1$
$x_{23} = 1$
$x_{14} = 1$
$x_{05} = 1$ ←

$s = (n+1)(v) + j$

$v, j = \lfloor s/(n+1) \rfloor, s \bmod (n+1)$

<should also work for tsp>



same thing!

L = 1,1 3,2 5,3 1,4 3,5

hl every v once in a cycle, except v_0 (ρ_0)

$$\rho_0 \sum_{v=0}^{r(n)} \left(1 - \sum_{j=0}^{r(n)} x_{vj}\right)^2$$

h_2 every j once in a cycle, including 0 & n (p_1)

$$p_1 \sum_{j=0}^{r(n+1)} \left(1 - \sum_{v=0}^{r(n)} x_{vj}\right)^2$$

penalties for $x_{01}, x_{02}, \ldots x_{(n-1)}$ (p_2)

$$p_2 \sum_{j=1}^{r(n)} x_{vj}$$

h_3 every u, v is in graph, but penalize $u = v$ (p_3)

@tsp

h_4 minimize total distance traveled (p_4)

$$\sum_{u \in \text{loc}} p_4 \sum_{\substack{v \in \text{loc} \\ v \neq u}} W_{uv} \sum_{j=0}^{r(n)} x_{uj} x_{v\,j+1}$$

penalty values $0 < (p_4) \max(W_{uv}) < p_0 = p_2 = p_3$

(B) (A)

knapsack $n = 5$

$$W = \sum_{\alpha=0}^{r(n)} w_\alpha x_\alpha \qquad w = 13, 17, 27, 23, 33$$

$$C = \sum^{r(n)} c_\alpha x_\alpha \qquad c = 10, 50, 40, 50, 20,$$

$\alpha = 0$

$W = 42$

a index: $a \in r(n) = 1 \iff$ in knapsack

y index: $y \in r(W) = 1 \iff$ knapsack weights n

h_5 knapsack weight can only be 1 value ρ_5

$$\rho_5 \left(1 - \sum_{n=0}^{r(n)} y_n\right)^2$$

h_6 weight of knapsack = sum of items ρ_6

$$\rho_6 \left(\sum_{n=0}^{r(w)} n y_n - \sum_{a=0}^{r(n)} w_a x_a\right)^2$$

h_7 maximize value of items ρ_7

$$-\rho_7 \sum_{a=0}^{r(n)} c_a x_a$$

penalty values $0 < (\rho_7)_B \max(c_a) < \rho_5 = \rho_6$ (A)

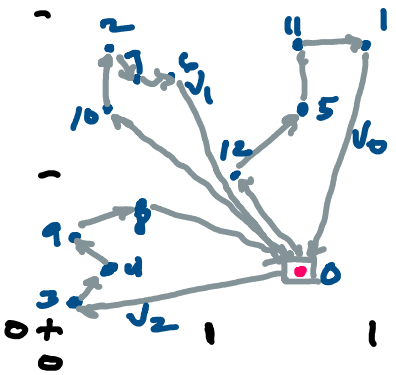
curp

$x_{vjk} = 1 \iff$ loc v is visited at step j by vehicle k

$c_a l_{ak} = 1 \iff$ capacity a has load a on vehicle k

$y_{nk} = 1 \iff$ weight y_n $(n \in [0 \dots r(\text{capacity} + 1))$

is weight of vehicle k



veh: 3,
capacity: 4

$v_{k=0}$ $x_{0,0} = x_{12,1} = x_{5,2} = x_{11,3} = x_{1,4} = x_{0,5}$

$v_{k=1}$ $x_{0,0} = x_{10,1} = x_{2,2} = x_{7,3} = x_{6,4} = x_{0,5}$

$v_{k=2}$ $x_{0,0} = x_{3,1} = x_{4,2} = x_{9,3} = x_{8,4} = x_{0,5}$

h_1 add index k

h_2 add index k

drop p_2

h_3 add index k

h_4 add index k

$\rightarrow \sum_{k=0}^{k} \dots x_{vjk}$

h_5 add index k $\rightarrow \sum_{k=0}^{k} \dots y_{ak}$

h_6 add index k $\rightarrow \sum_{k=0}^{k} \dots c_a l_{ak}$

drop h_7