500 tablematch

apr1/apr4 2022 shelat



### Gabriel García Marquez

# LOVE in the Time of Tindera





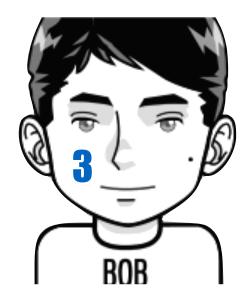
We have a group of suitors and reviewers

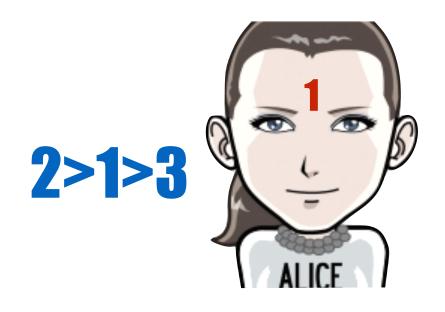


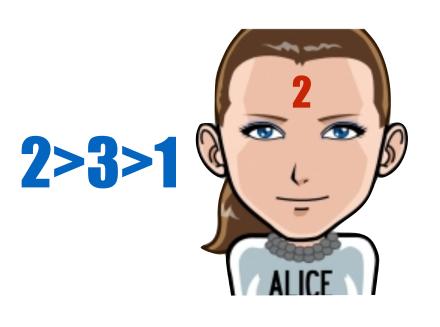




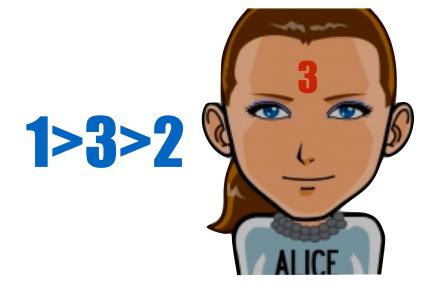








Each has preferences over the other group

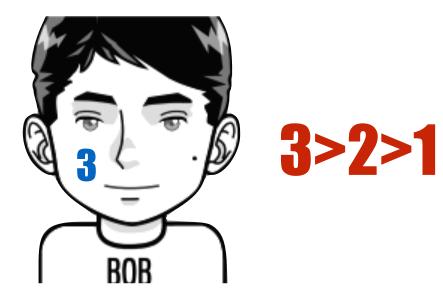


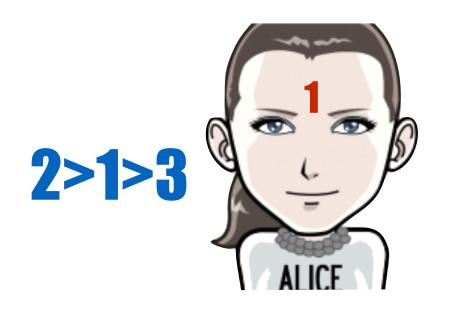


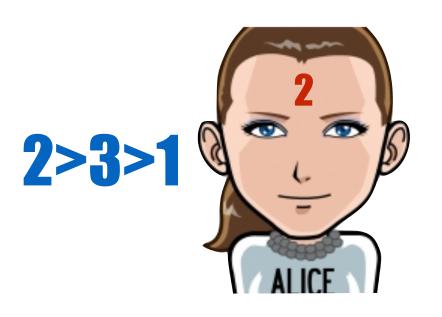
1>3>2



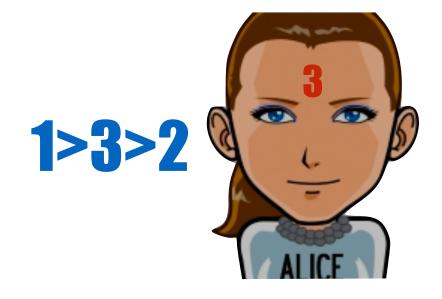








We seek a **stable matching** between the two

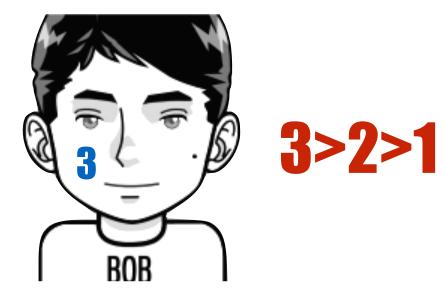


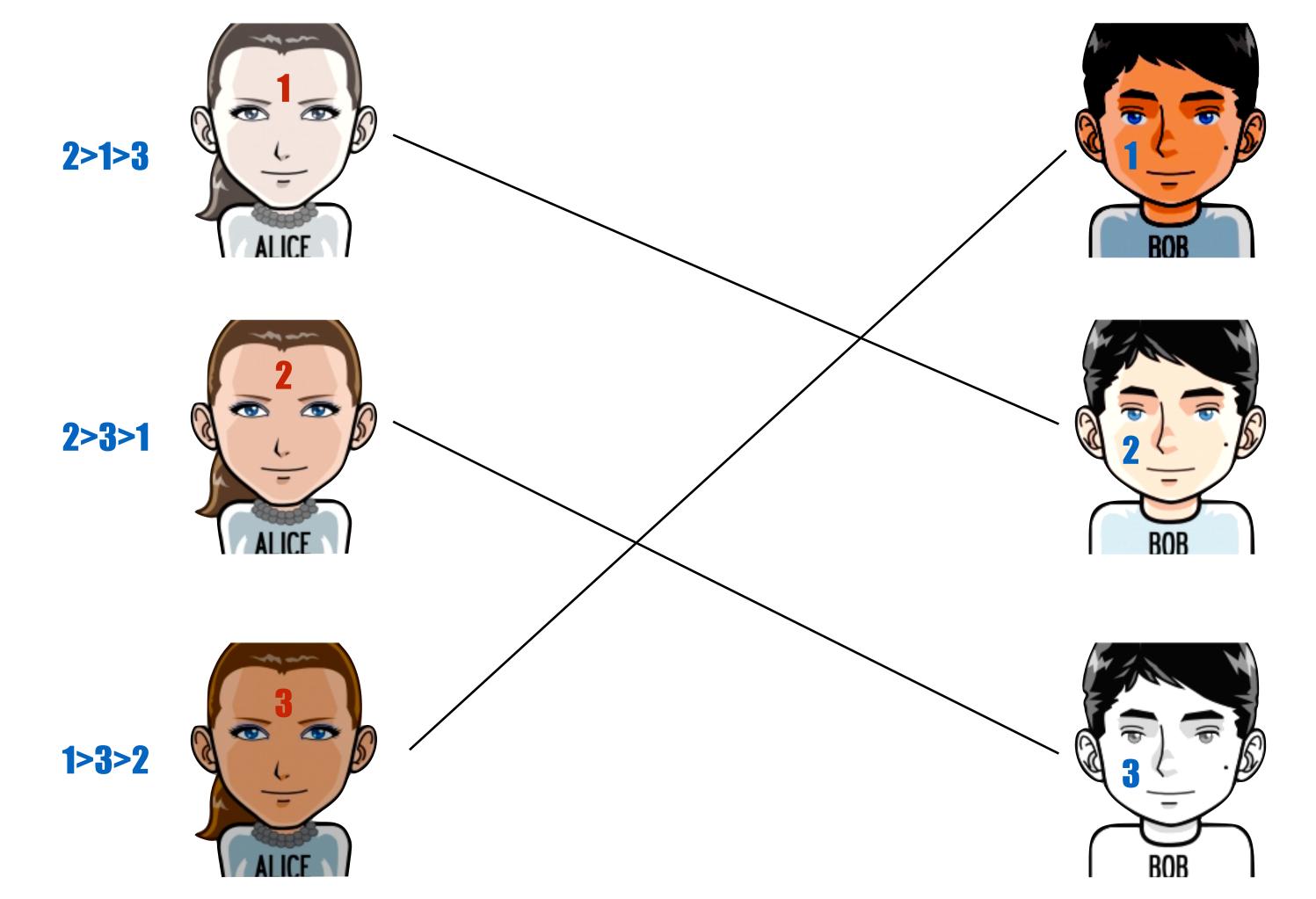






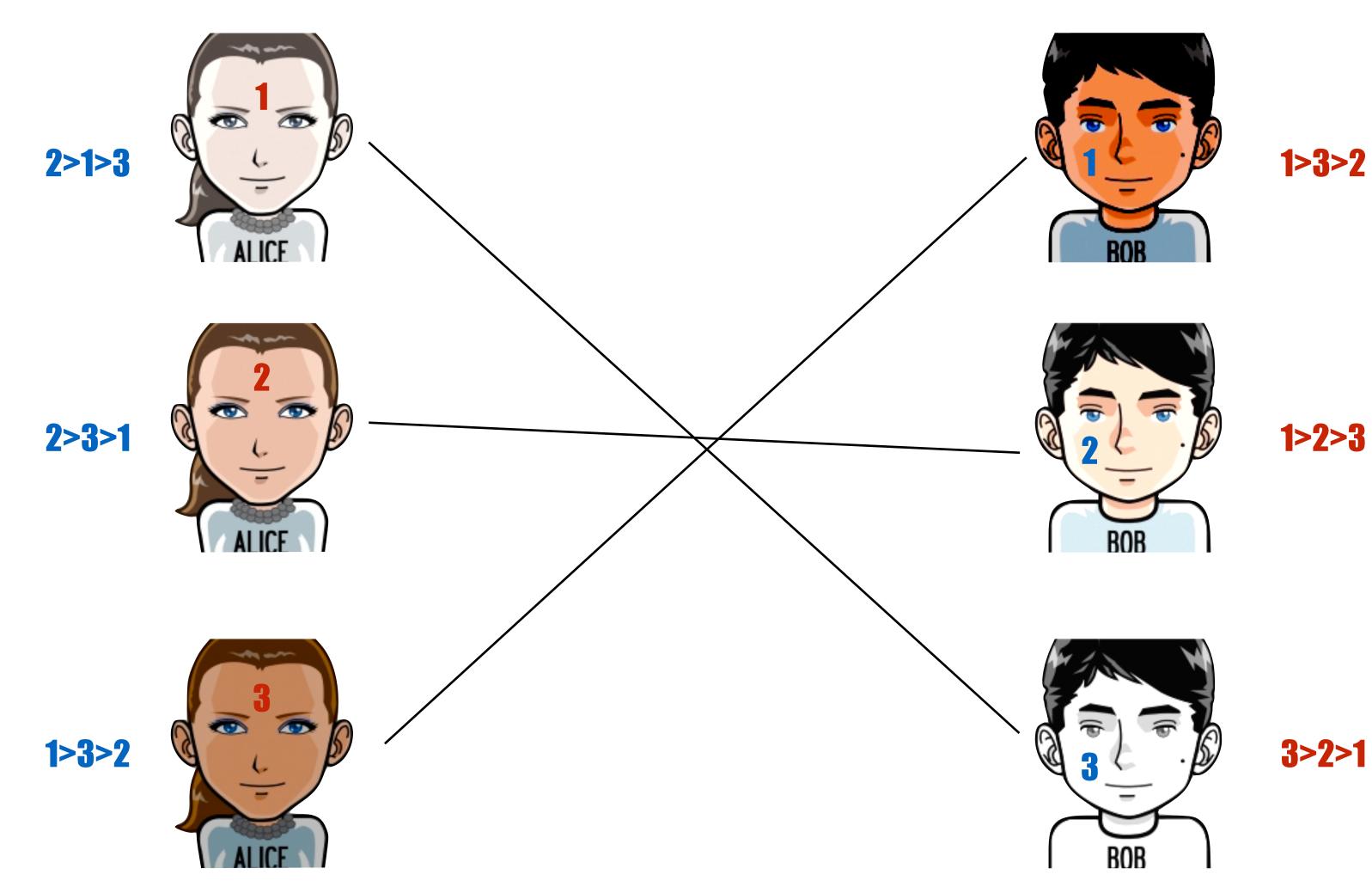






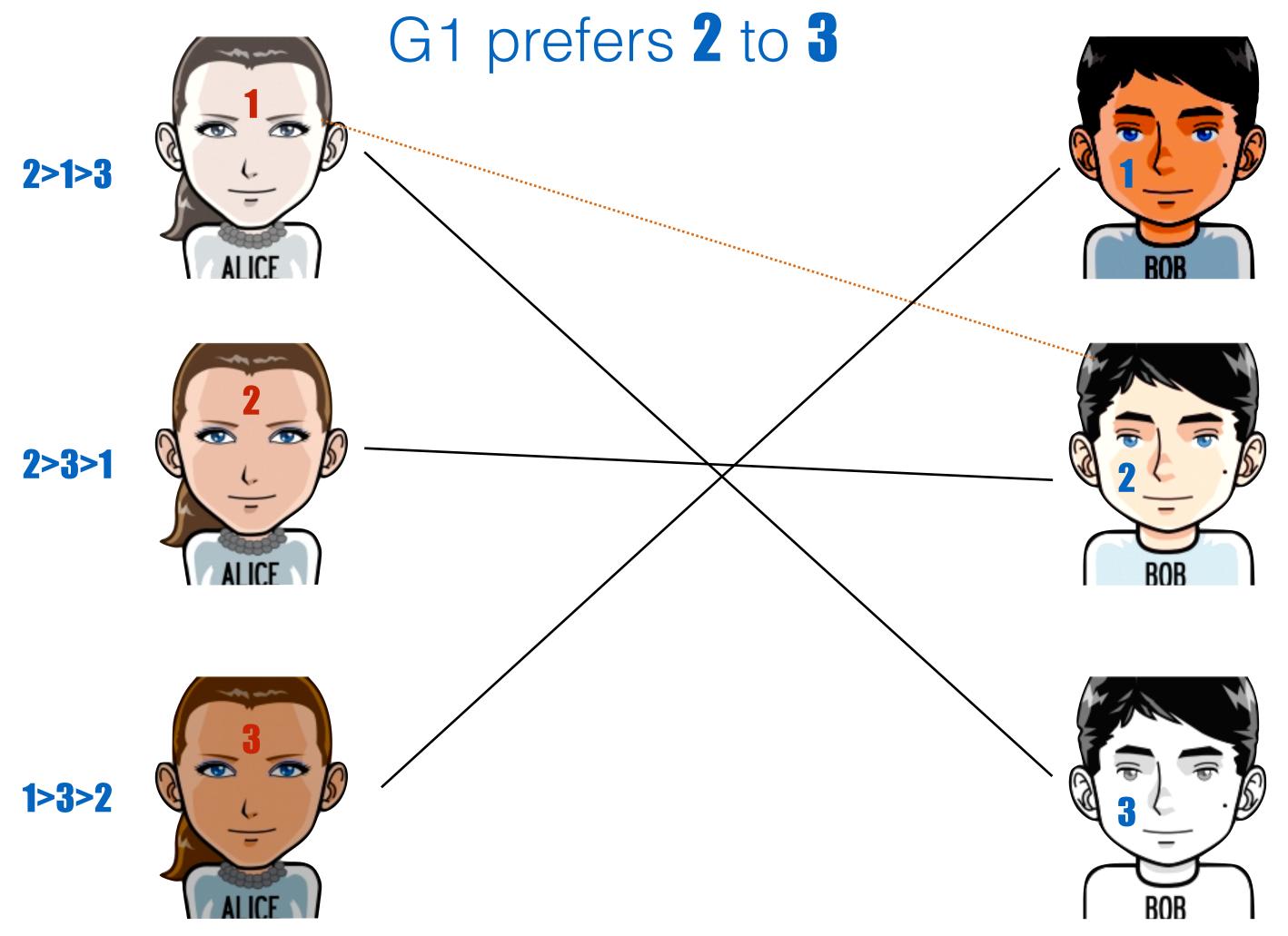
1>3>2





### Unstable Matching

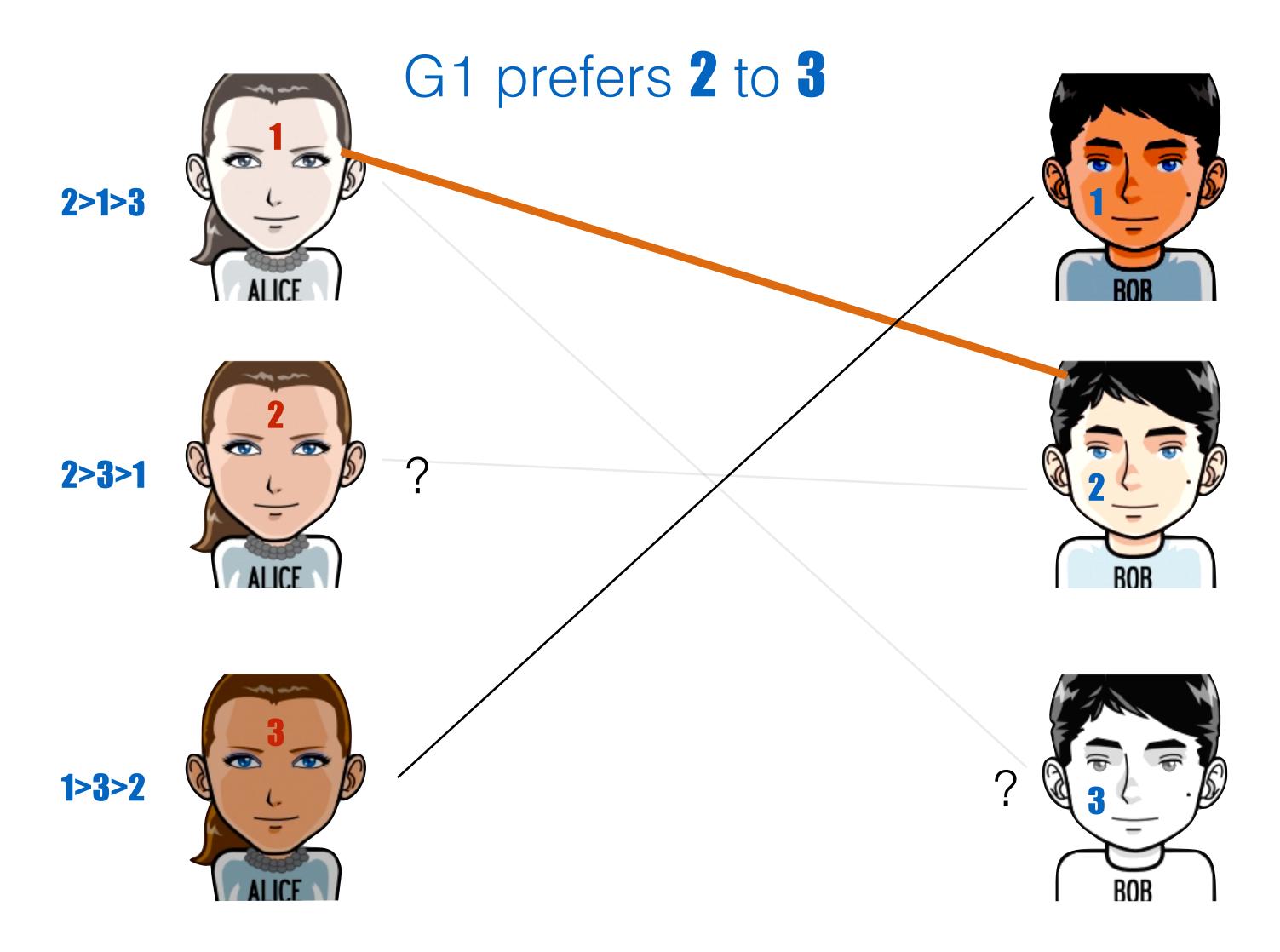
1>3>2



### Unstable Matching

1>3>2

B2 prefers 1 to 2



### Unstable Matching

1>3>2

B2 prefers 1 to 2

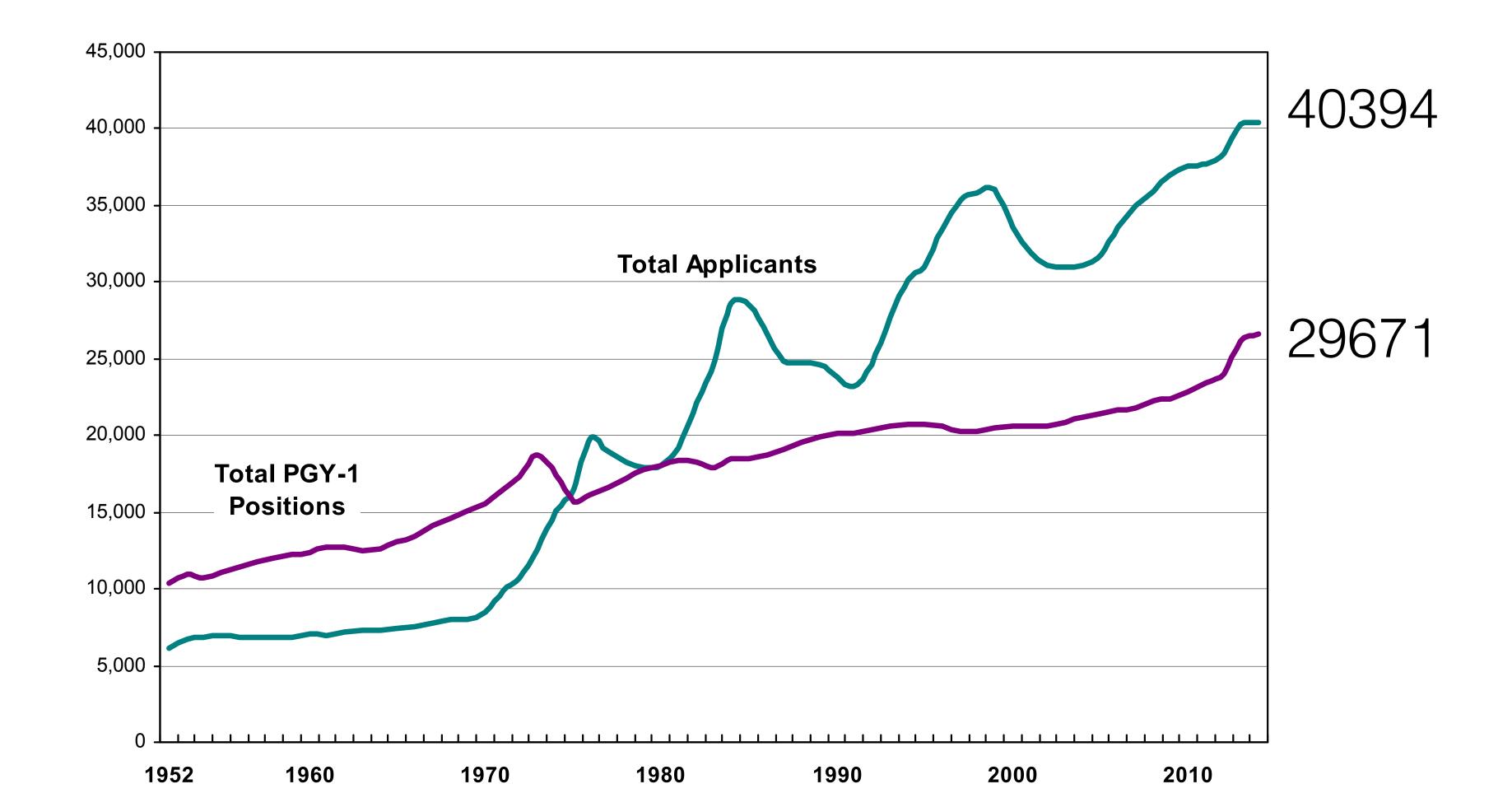
# Stable Matching

matching has many practical applications



Figure 1

Applicants and 1st Year Positions in The Match, 1952 - 2014



С	arms				
		Matched			
	Applicant Type	2013	Prior Year	Total	
		Graduates	Graduates <sup>1</sup>		
	CMG	2571	74	2645	
	IMG	146	353	499	
	USMG	23	2	25	
	TOTAL	2740	429	3169	





Established in collaboration with MIT







University of Virginia Chi Omega Bid Day 2012

## Definition: matchings

P =

R =

M =

## Definition: matchings

 $P = \{p_1, p_2, \dots, p_n\}$  $R = \{r_1, r_2, \dots, r_n\}$  $M = \{(p_{i_1}, r_{j_1}), \dots, (p_{i_n}, \dots, (p_{i_n})\}\}$ 

Each  $p_i(r_j)$  appears only one in a pairing. A matching is perfect if every  $p_i$  appears.

$$, r_{j_n})\}$$



Image credits: Julia Nikolaeva









# Definition: $P = \{p$

### Definition: preferences

 $P = \{p_1, p_2, \dots, p_n\}$ 

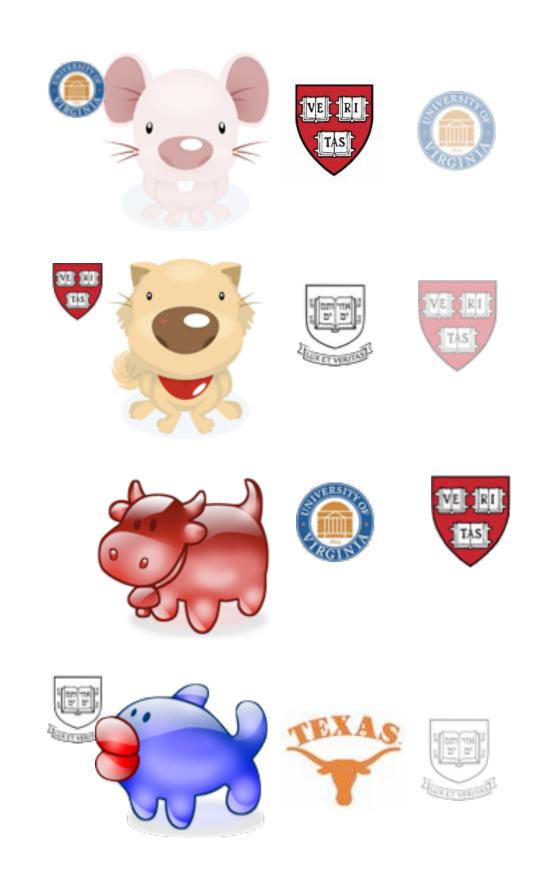


Image credits: Julia Nikolaeva



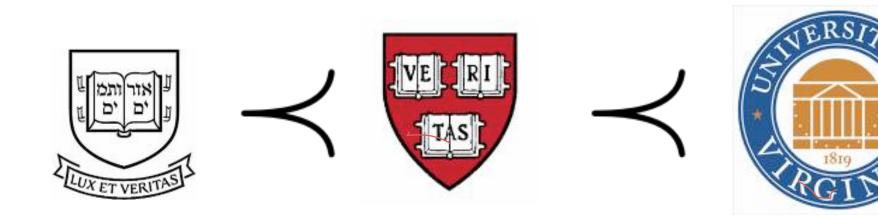






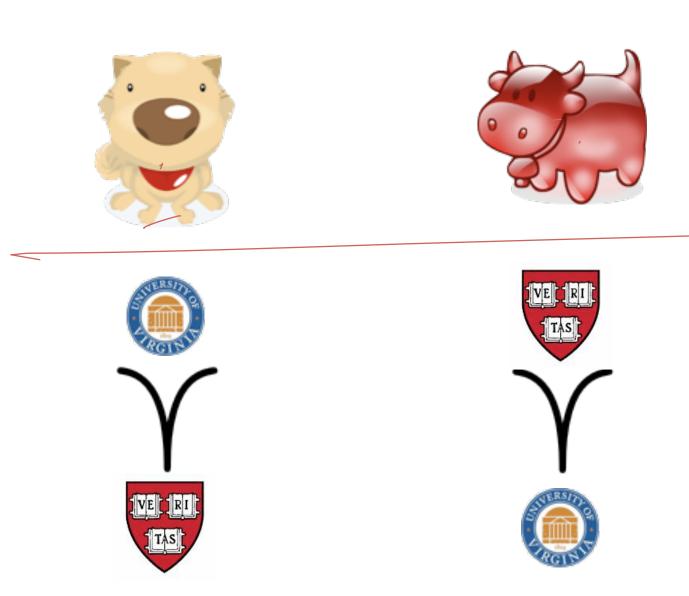
### $P = \{p_1, p_2, \dots, p_n\}$

*P*<sub>*i*</sub> has a preference relation on the set R



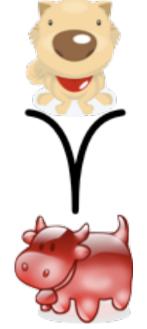
### Example: preferences

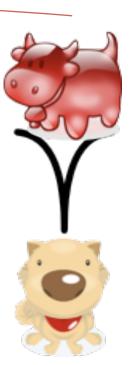
 $w_1 \prec_{m_i} w_4 \prec_{m_i} w_2 \prec_{m_i} w_8 \cdots w_n$ 

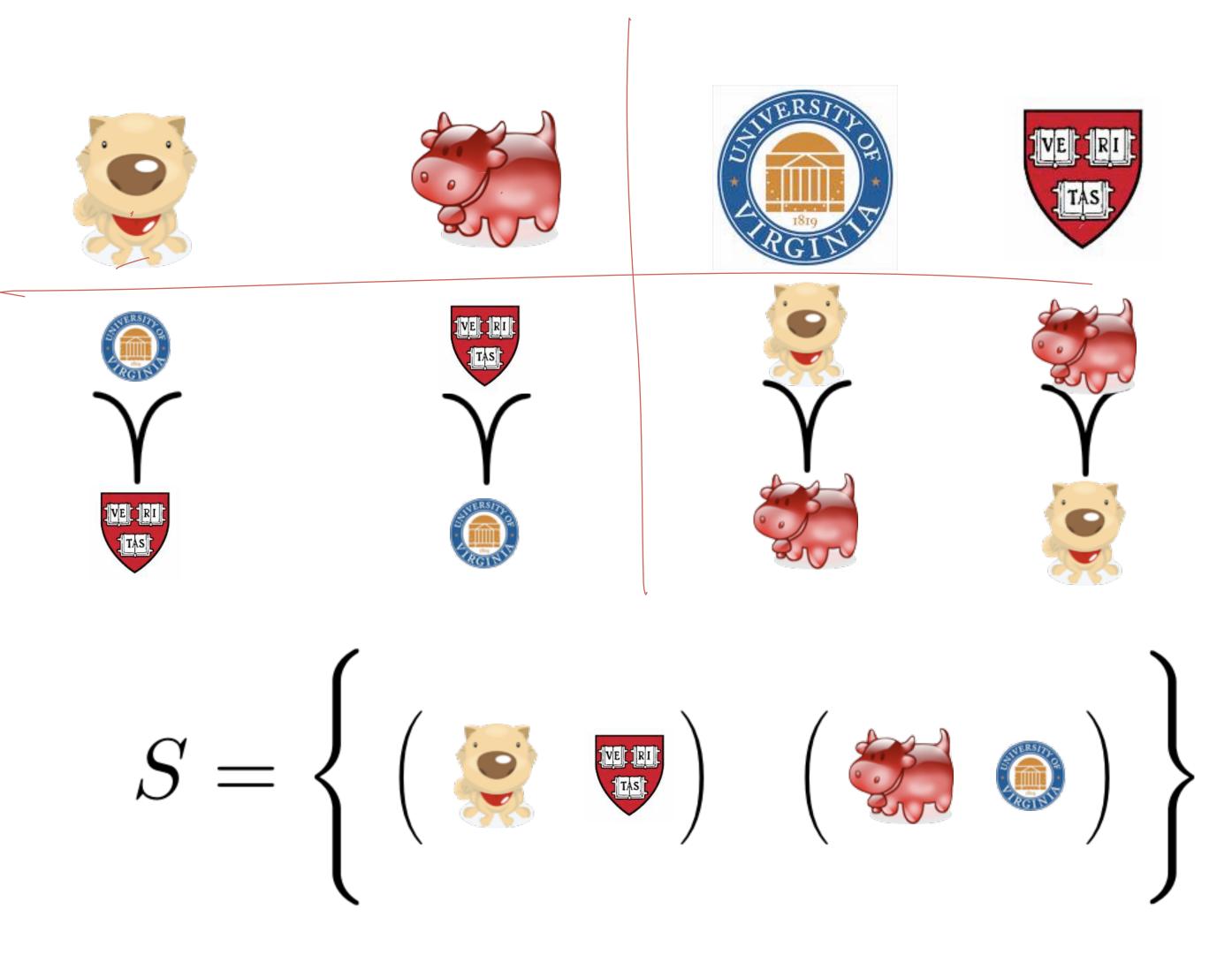


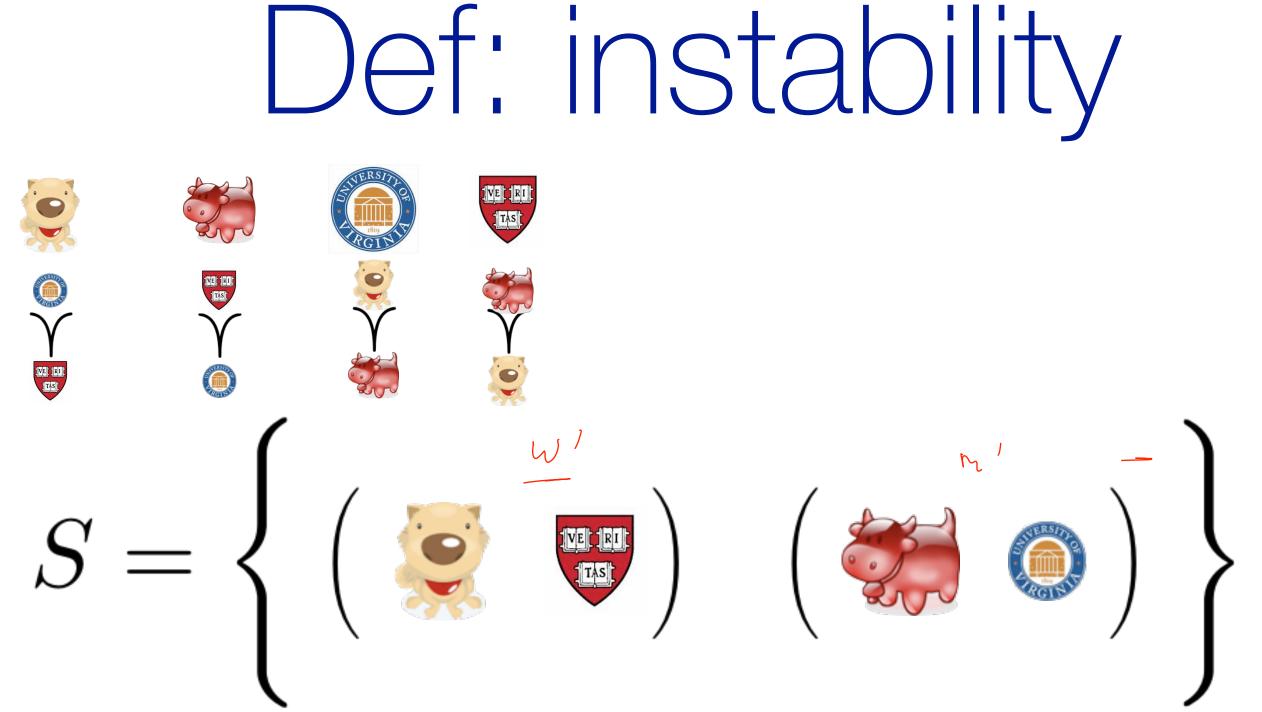


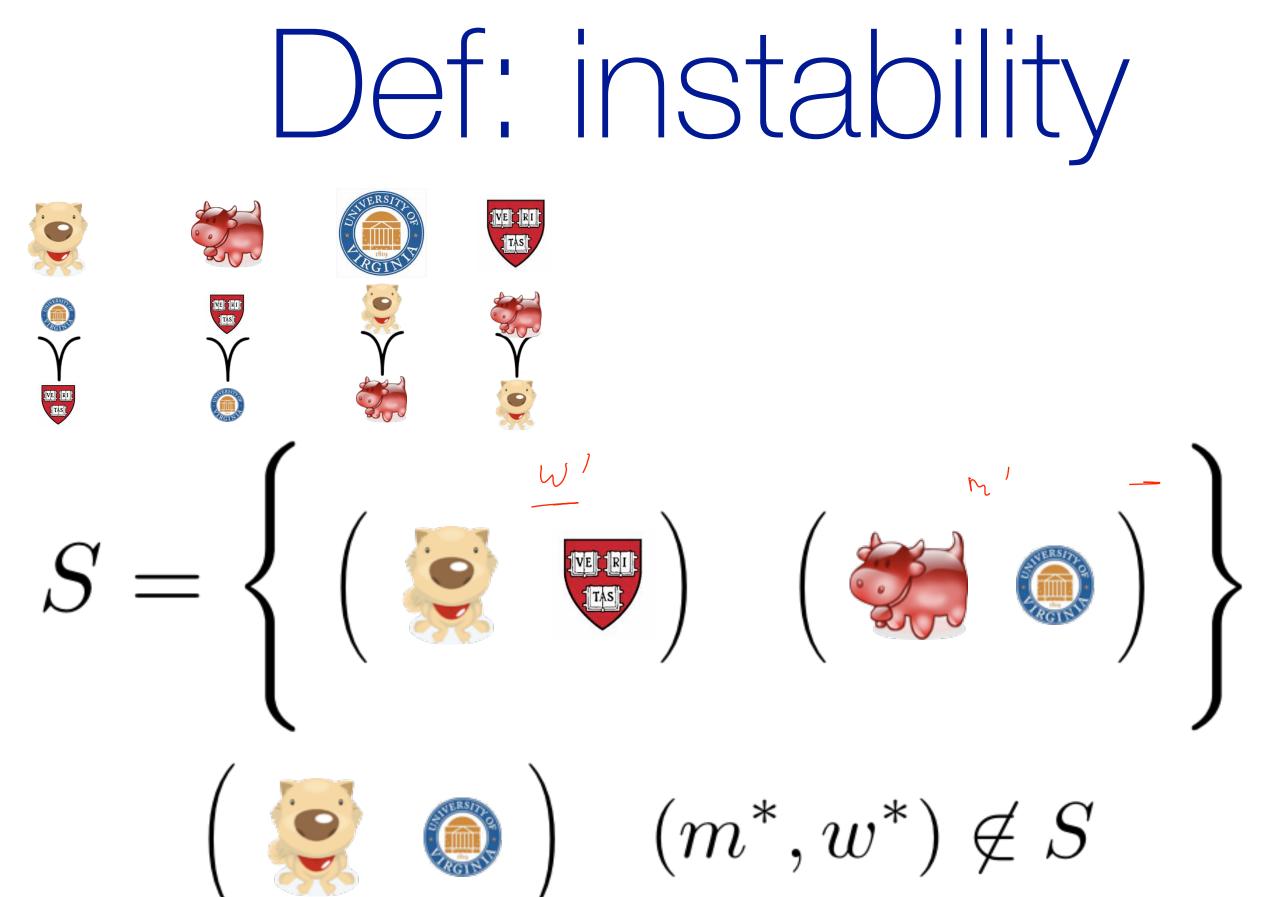












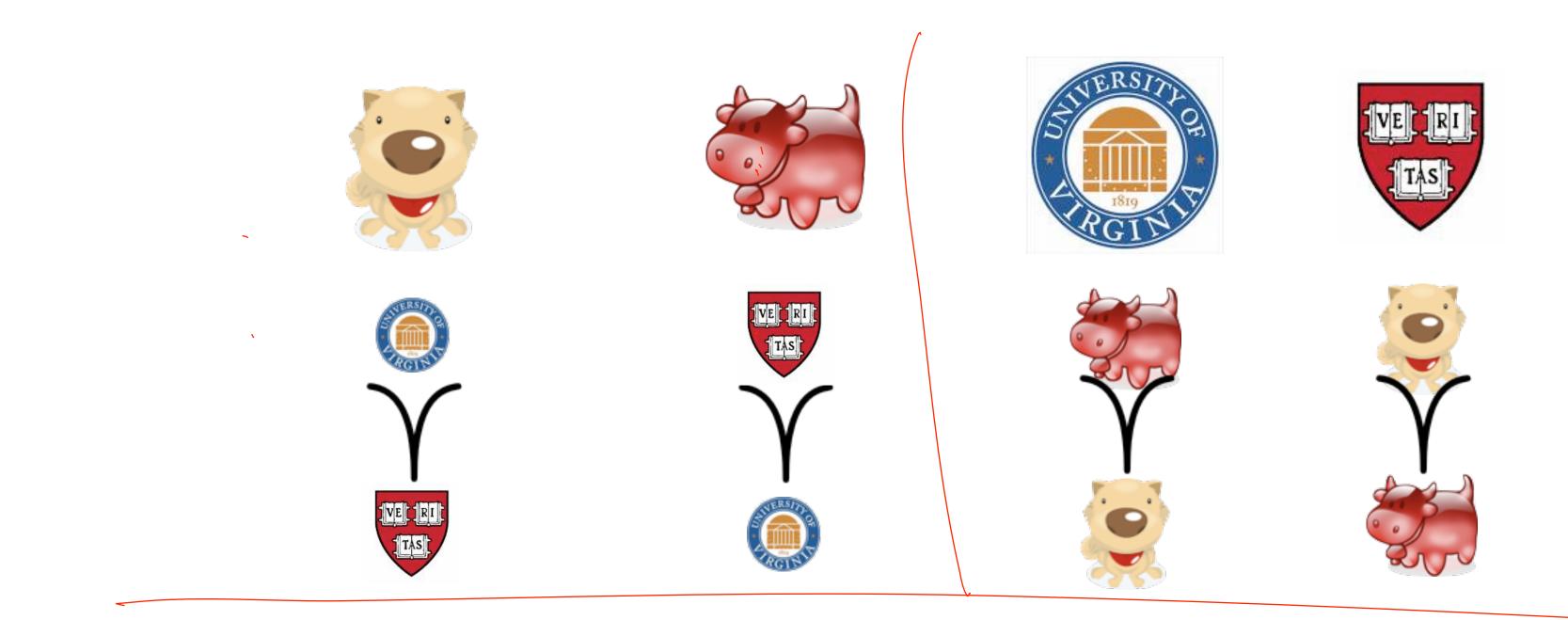
 $w' \prec_{m^*} w^*$ 

 $m' \prec_{w^*} m^*$ 

# $= \{ (s_1,r_1), (s_2,r_2), \dots (s_n,r_n) \}$ is a stable matching if

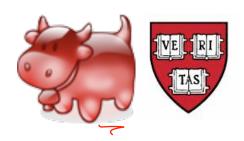
No unmatched pair (s\*,r\*) prefer each other to their partners in M







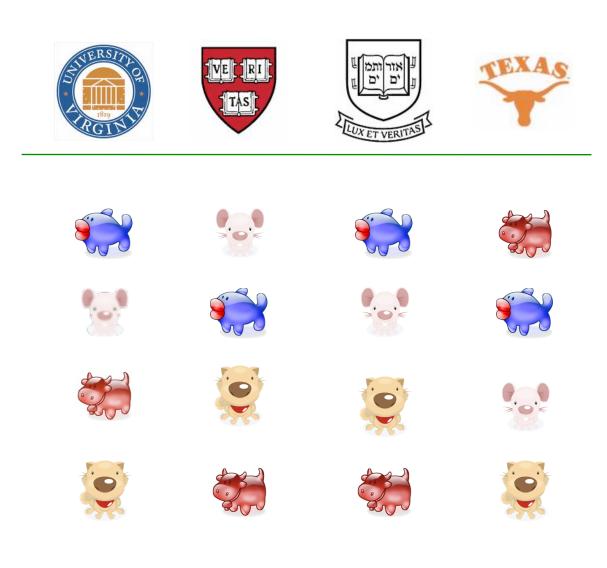
## Example 2



## Prove: for every input



## there exists a stable matching.



## proposal algorithm

STABLEMATCH $(M, W, \prec_m, \prec_w)$ 

1	Initialize all $m, w$ to be FREE
2	while $\exists FREE(m)$ and hasn't pro
3	<b>do</b> Pick such an <i>m</i>
4	Let $w \in W$ be highest-r
5	if $FREE(w)$
6	then Make a new par
7	elseif $(m', w)$ is paired
8	<b>do</b> Break pair $(m', m')$
9	Make pair ( <i>m</i> , <i>u</i>
10	return Set of pairs

oposed to all W

ranked to whom *m* has not yet proposed

air (m, w)l and  $m' \prec_w m$ , w) and make m' free w)

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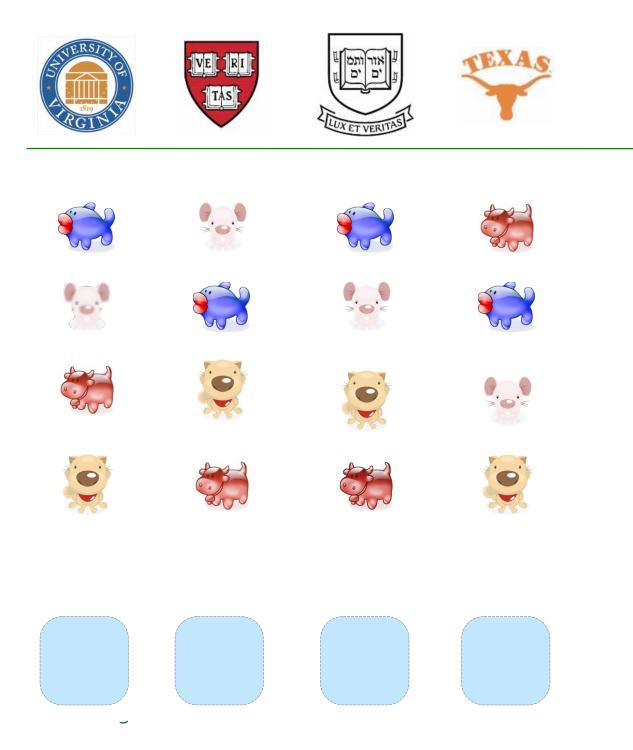


















































TEXAS

109: 100: 1635:







SUPERSITE P

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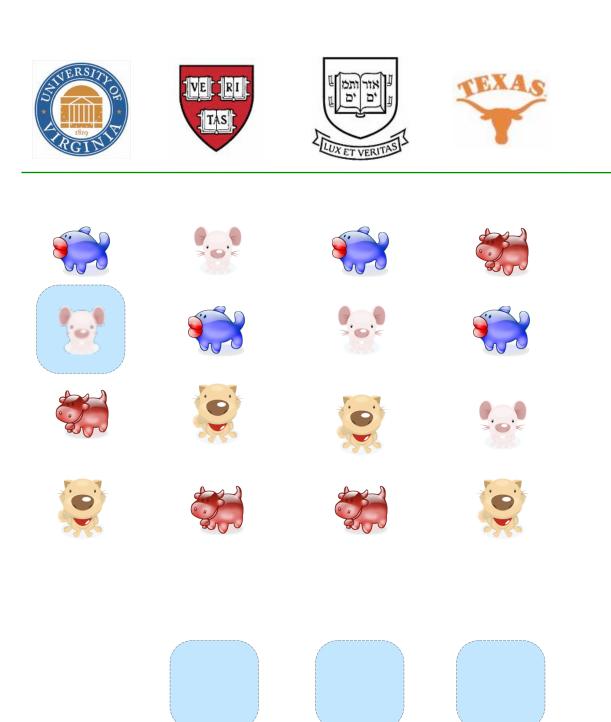


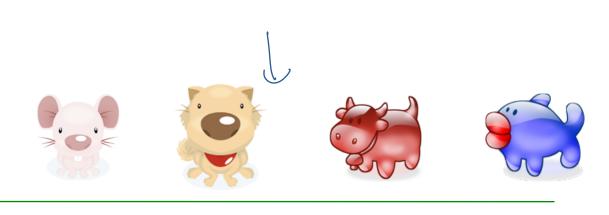










































































































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LUX ET VERITAS

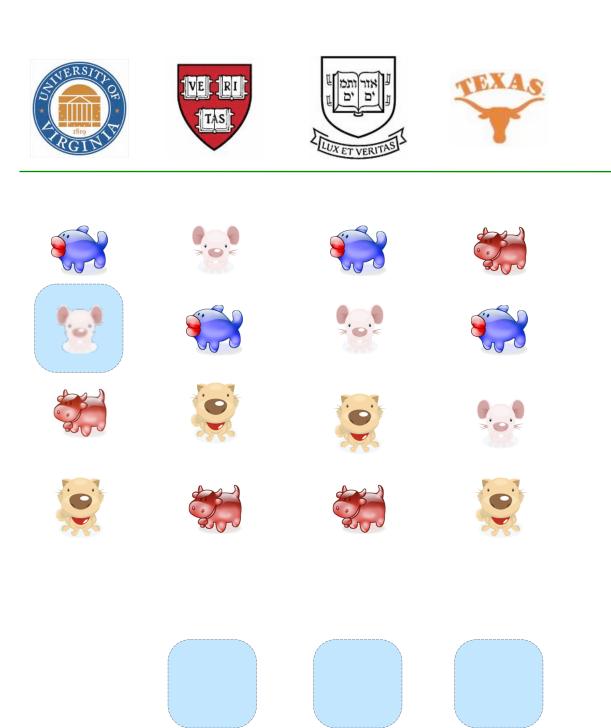
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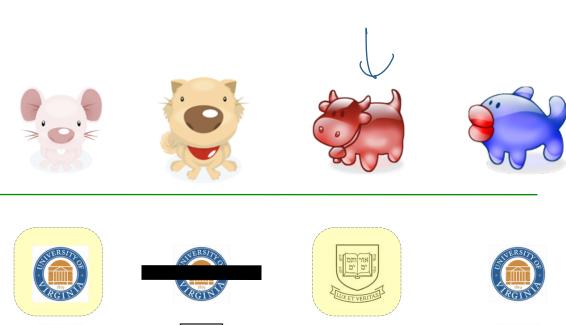
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LLUX ET VERITIST

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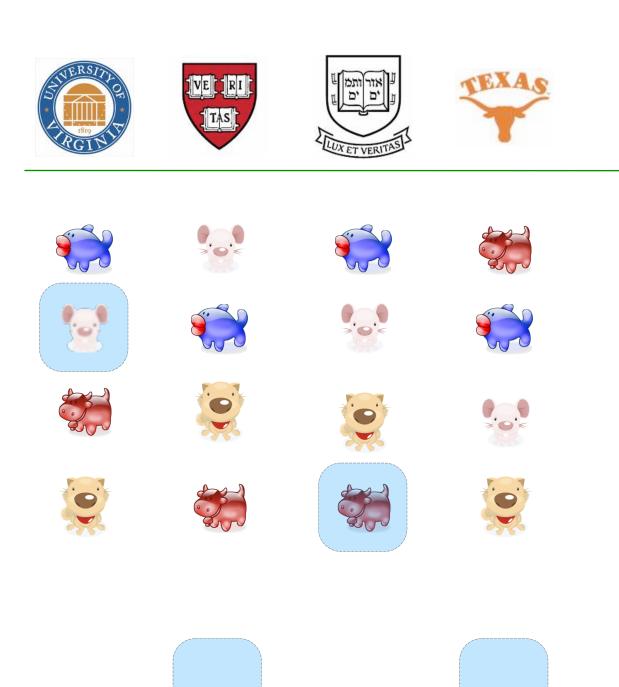
















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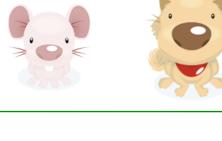


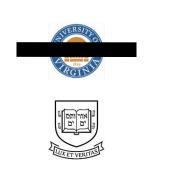


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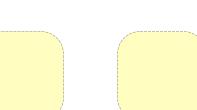




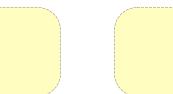


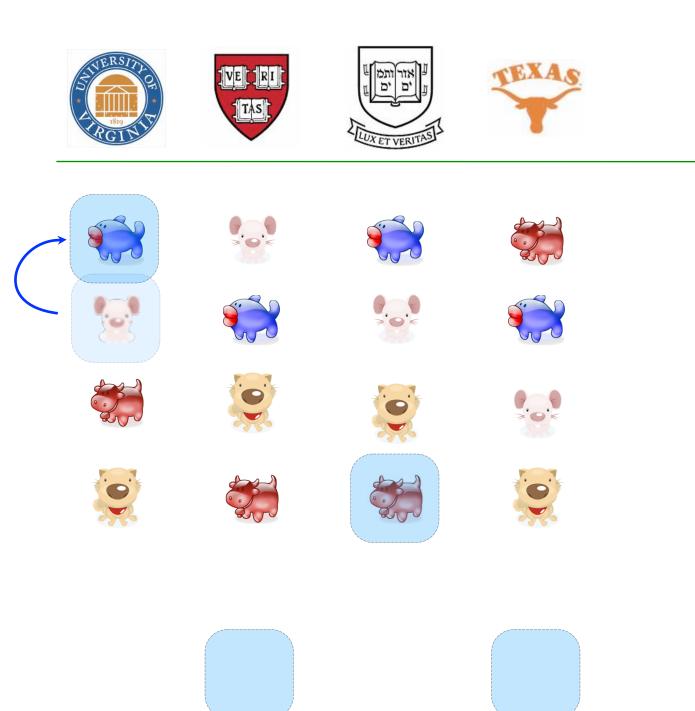


















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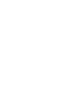


























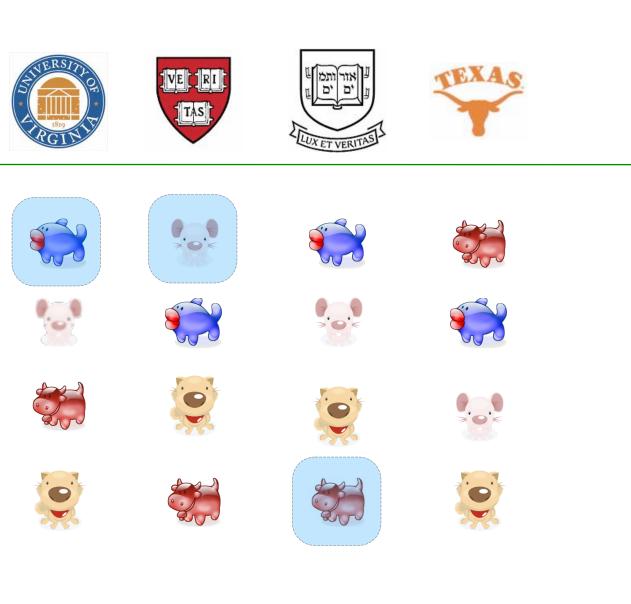


















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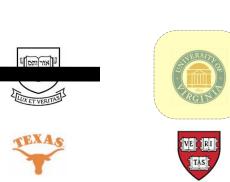


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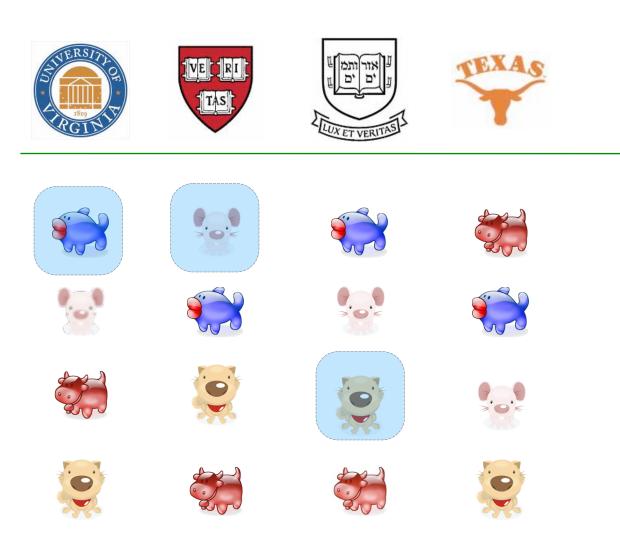
















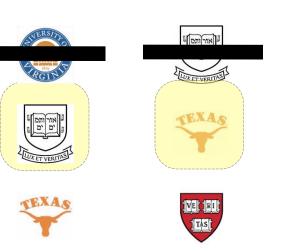
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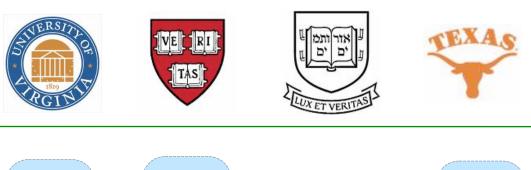








RSTOP C





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### Proposal algorithm ends

## Proposal algorithm ends

 $O(n^2)$  steps each m proposes at most once to each w. each m proposes at most n times. size of M is at most n.

### output is a matching

STABLEMATCH $(M, W, \prec_m, \prec_w)$ 

1	Initialize all $m, w$ to be FREE
2	while $\exists FREE(m)$ and hasn't pro
3	<b>do</b> Pick such an <i>m</i>
4	Let $w \in W$ be highest-r
5	if free $(w)$
6	then Make a new par
7	elseif $(m', w)$ is paired
8	<b>do</b> Break pair $(m', m')$
9	Make pair ( <i>m</i> , <i>u</i>
10	return Set of pairs

- oposed to all W
- ranked to whom *m* has not yet proposed
- air (m, w)d and  $m' \prec_w m$ , w) and make m' free w)

STABLEMATCH $(M, W, \prec_m, \prec_w)$ 

1	Initialize all $m, w$ to be FREE
2	while $\exists FREE(m)$ and hasn't pro
3	<b>do</b> Pick such an <i>m</i>
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10	return Set of pairs

oposed to all W

ranked to whom *m* has not yet proposed

air (m, w)l and  $m' \prec_w m$ , w) and make m' free w)

### output is perfect

### if $\exists m$ who is free, then $\exists w$ who has not been asked

### output is perfect

### output is stable

### Spse not. $\exists (m^*, w), (m, w^*) \in S$ $w \prec_{m^*} w^* m \prec_{w^*} m^*$

### output is stable

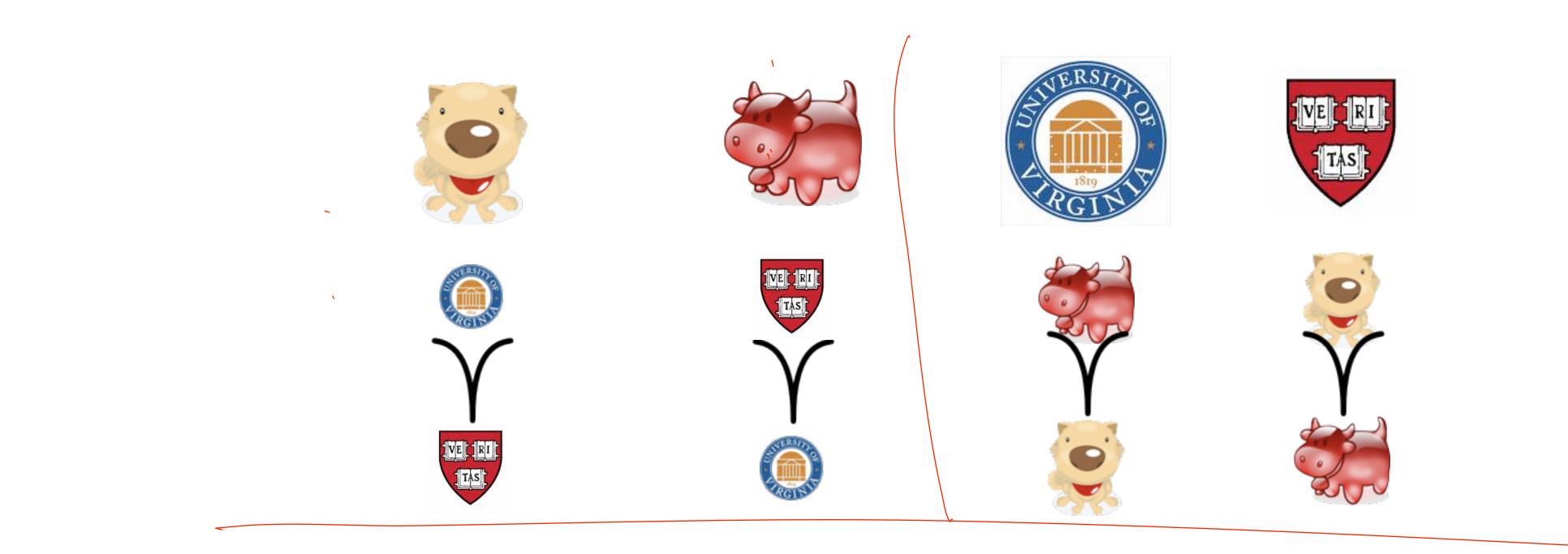
Spse not.  $\exists (m^*, w), (m, w^*) \in S$   $w \prec_{m^*} w^* m \prec_{w^*} m^*$ 

m\* last proposal was to w and must have been rejected by  $m^* \prec_{w^*} m'$ then either  $m' \prec_{w^*} m$  or m'=m which contradicts assumption  $m \prec_{w^*} m^*$ 

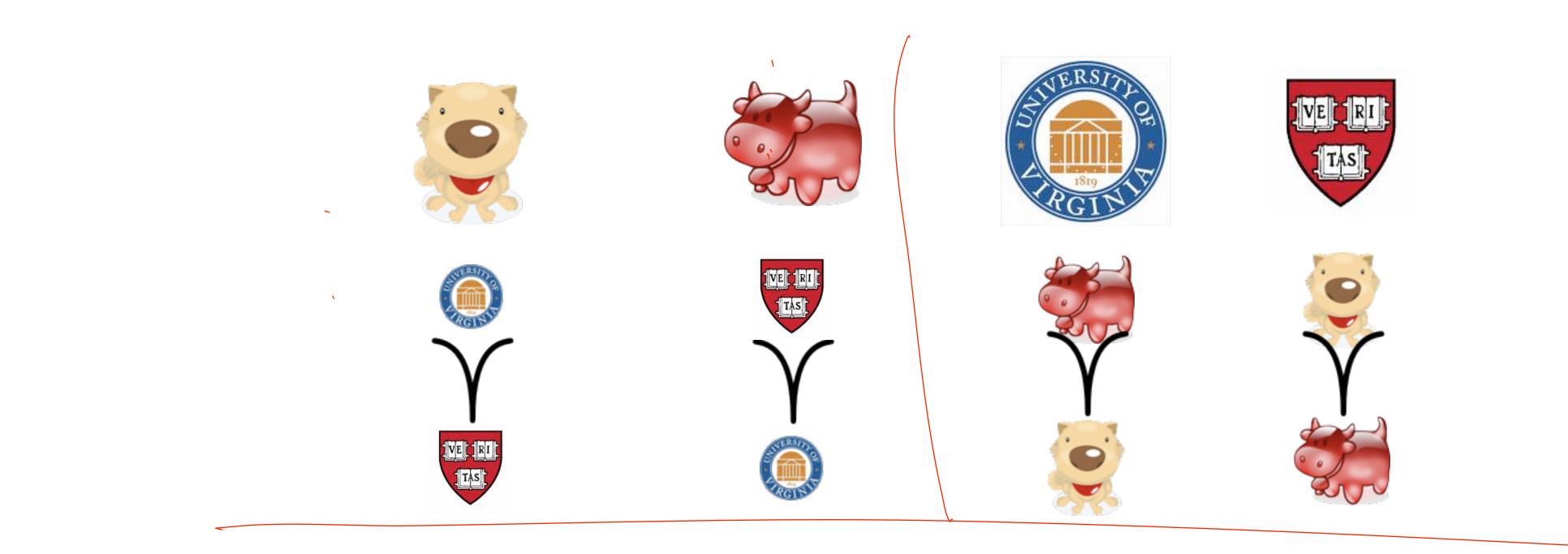
### output is stable

but  $w \prec_{m^*} w^*$  and so m<sup>\*</sup> must have already asked w<sup>\*</sup>

### Proposer wins



### Proposer wins

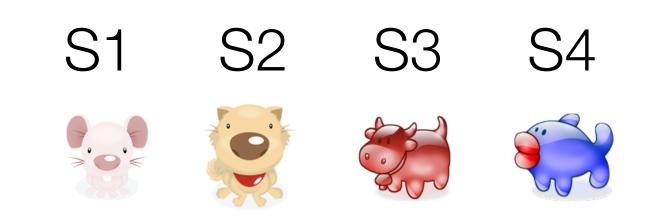


### Remarkable theorem

w is valid for m: best(m):

### GS is Suitor-optimal.

## GS matching vs R-opt



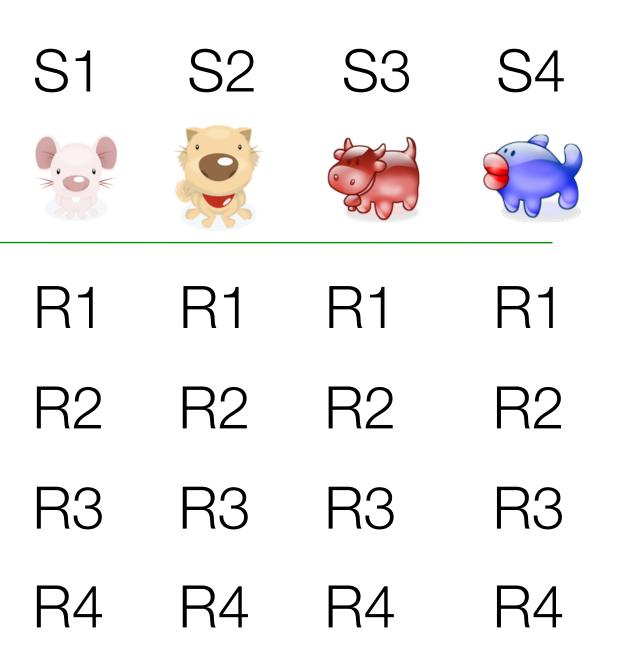


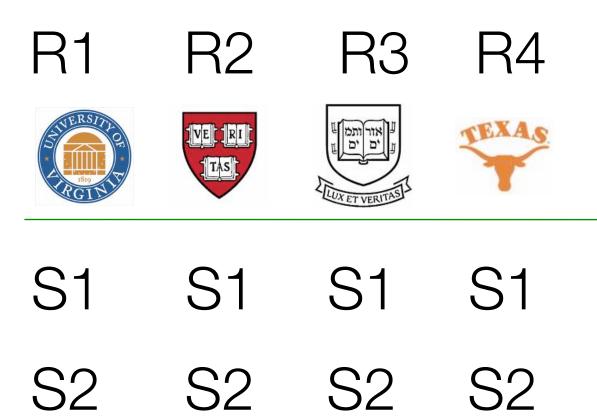
S3 S3 S3

S4 S4 S4

S3

S4



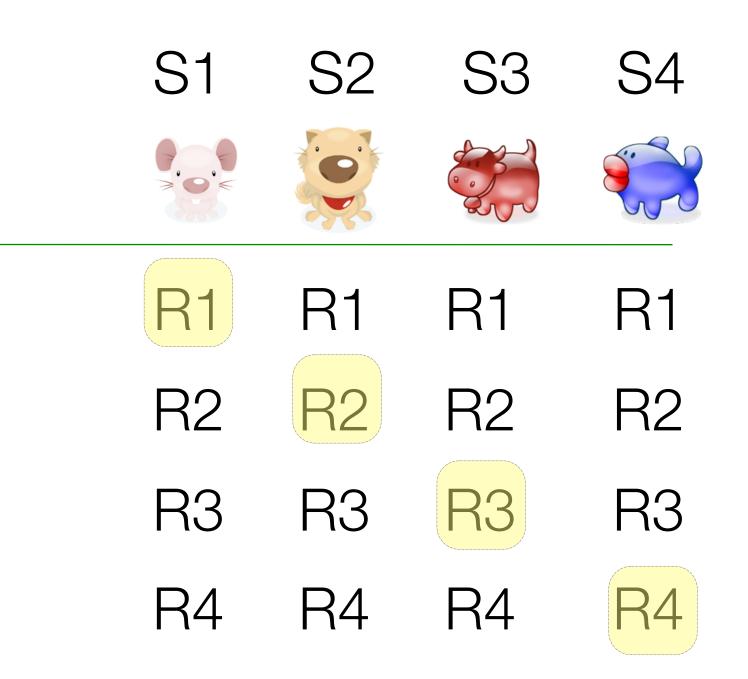


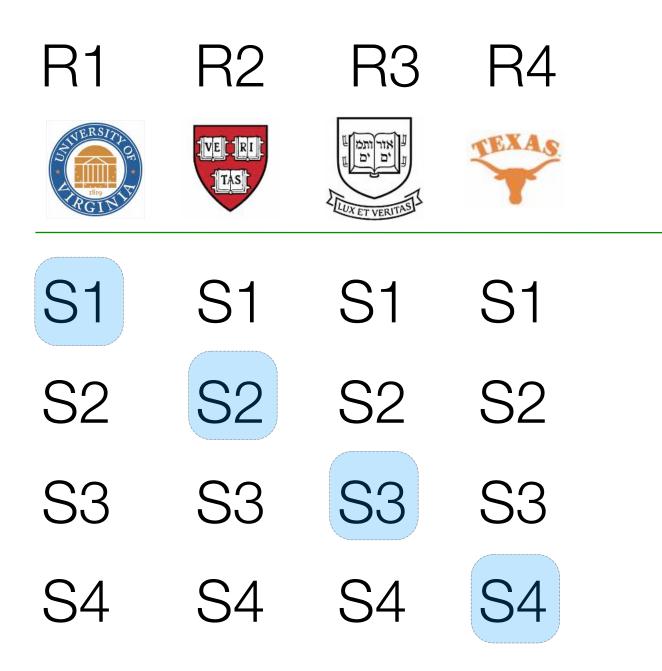
S3 S3 S3

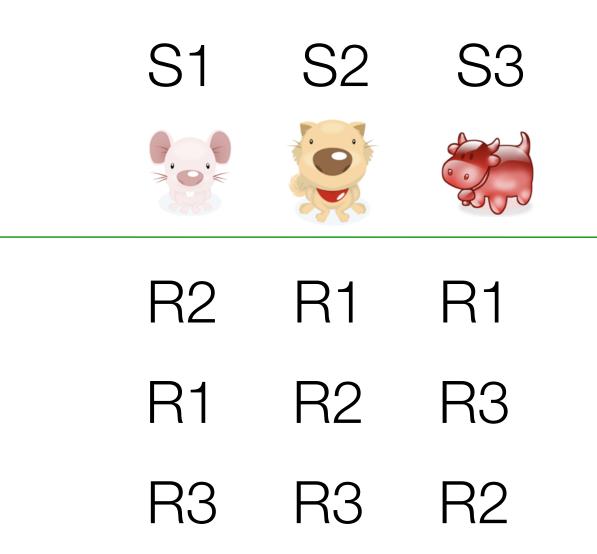
S4 S4 S4

S3

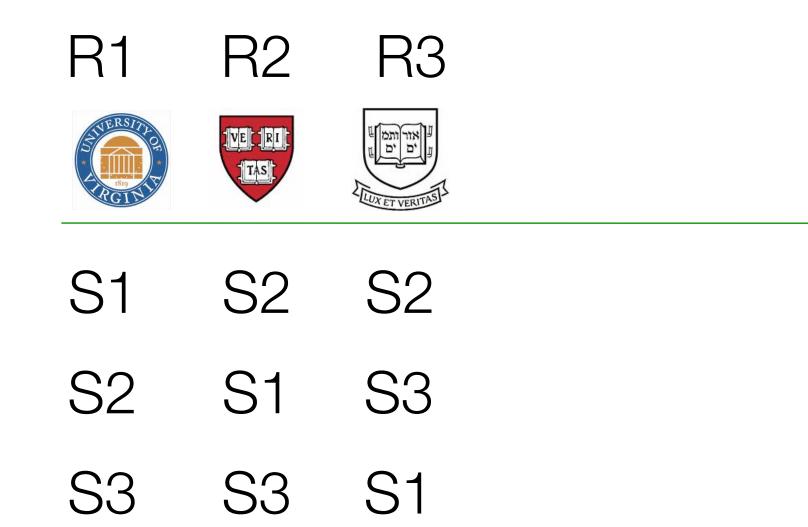
S4

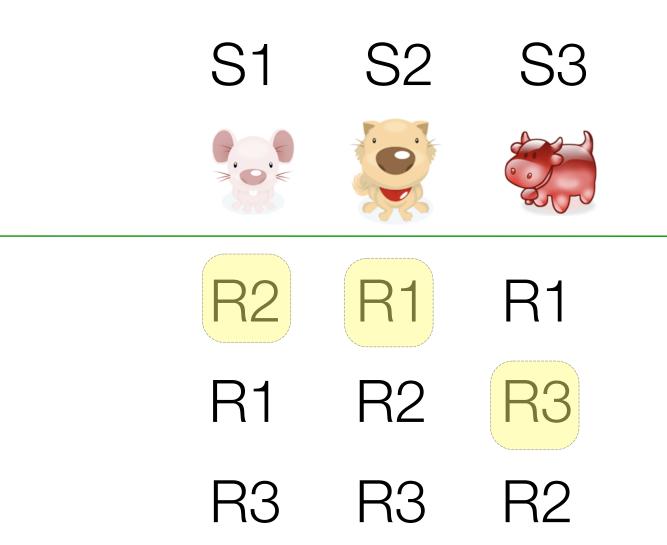






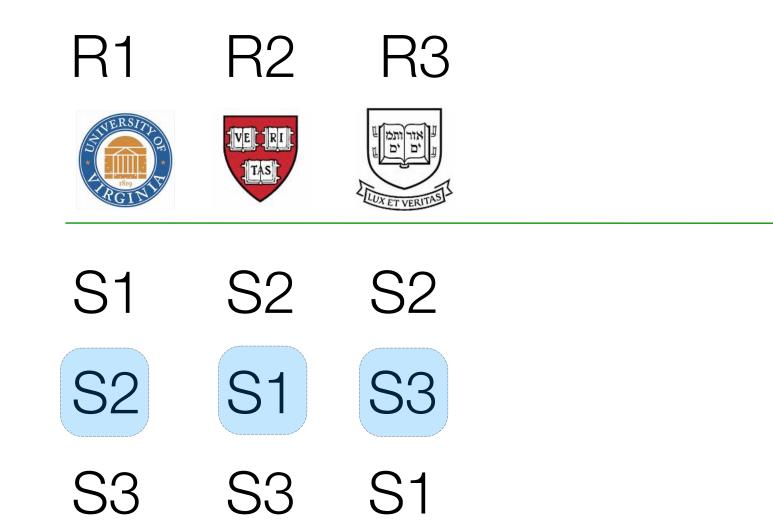
### Not honest



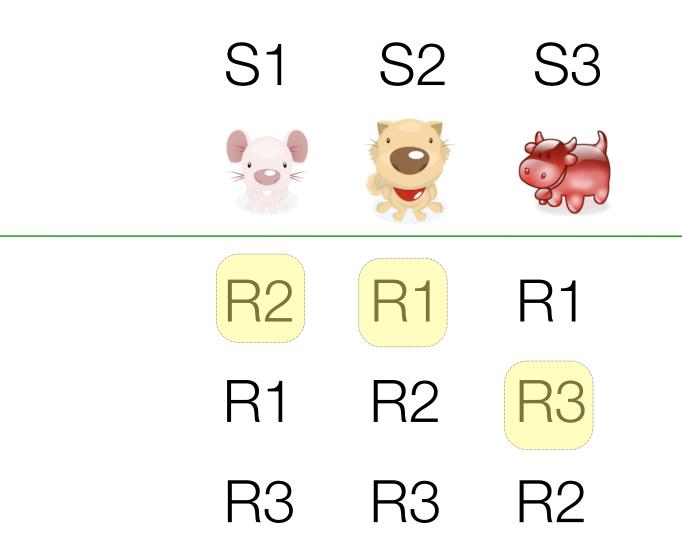


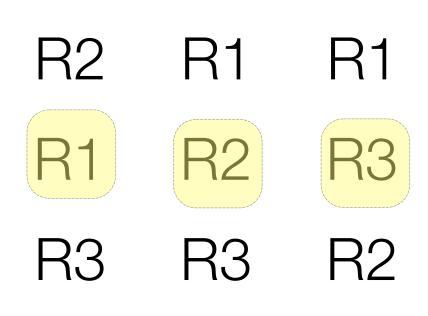
R2 R1 R1R2 R3 R1R3 R3 R2

### Not honest

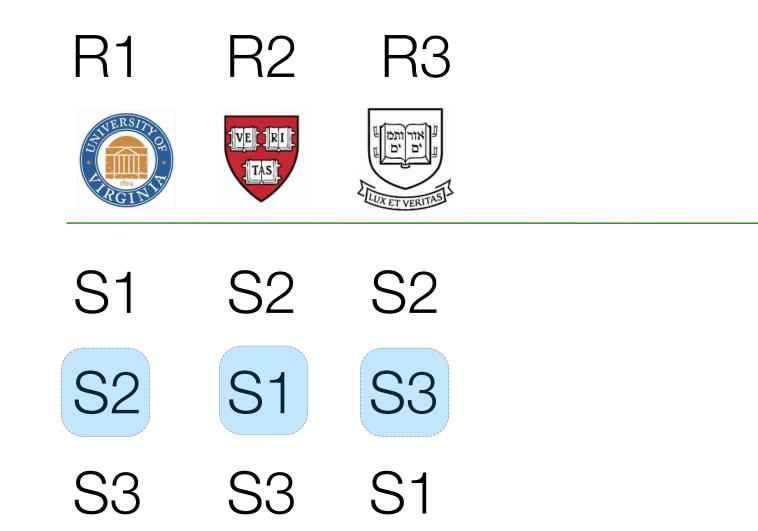


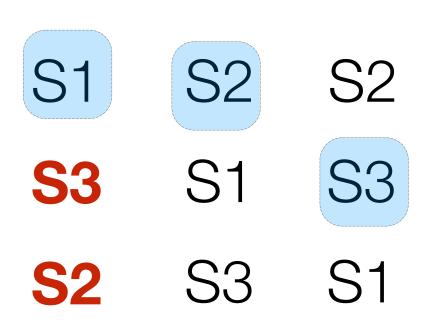






### Not honest







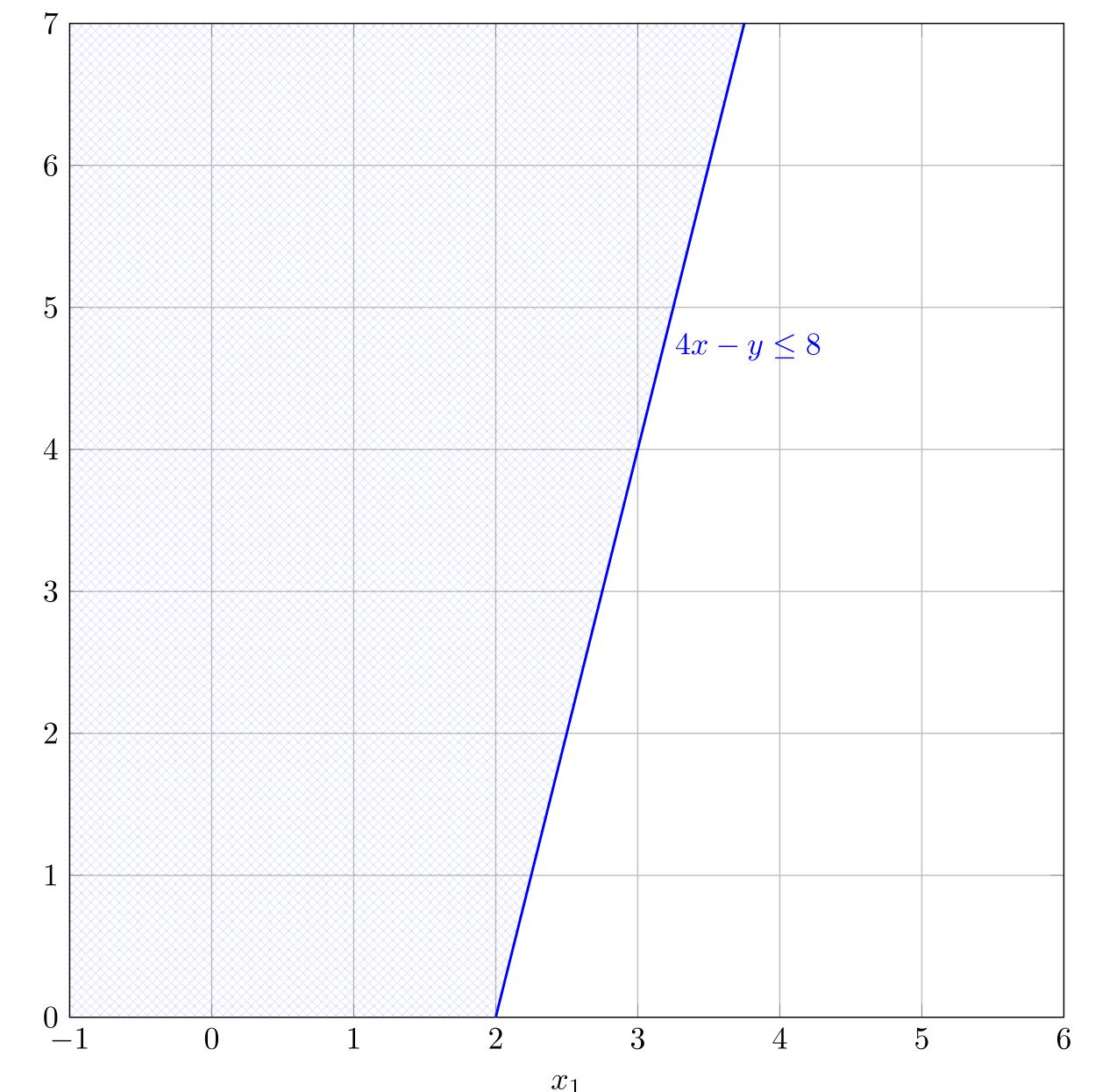
### Guns and butter



 $\max x + y$  $4x - y \leq 8$  $2x + y \leq 10$  $5x - 2y \geq -2$  $x, y \geq 0$ 

http://i16.photobucket.com/albums/b20/safebuy/ak47/ak47-electric lg.jpg http://2.bp.blogspot.com/ NX4zcMNX4VE/Sb8MQfffllI/AAAAAAAAAL0/eu4J0dfFhJE/s400/gourmet-butter.jpg

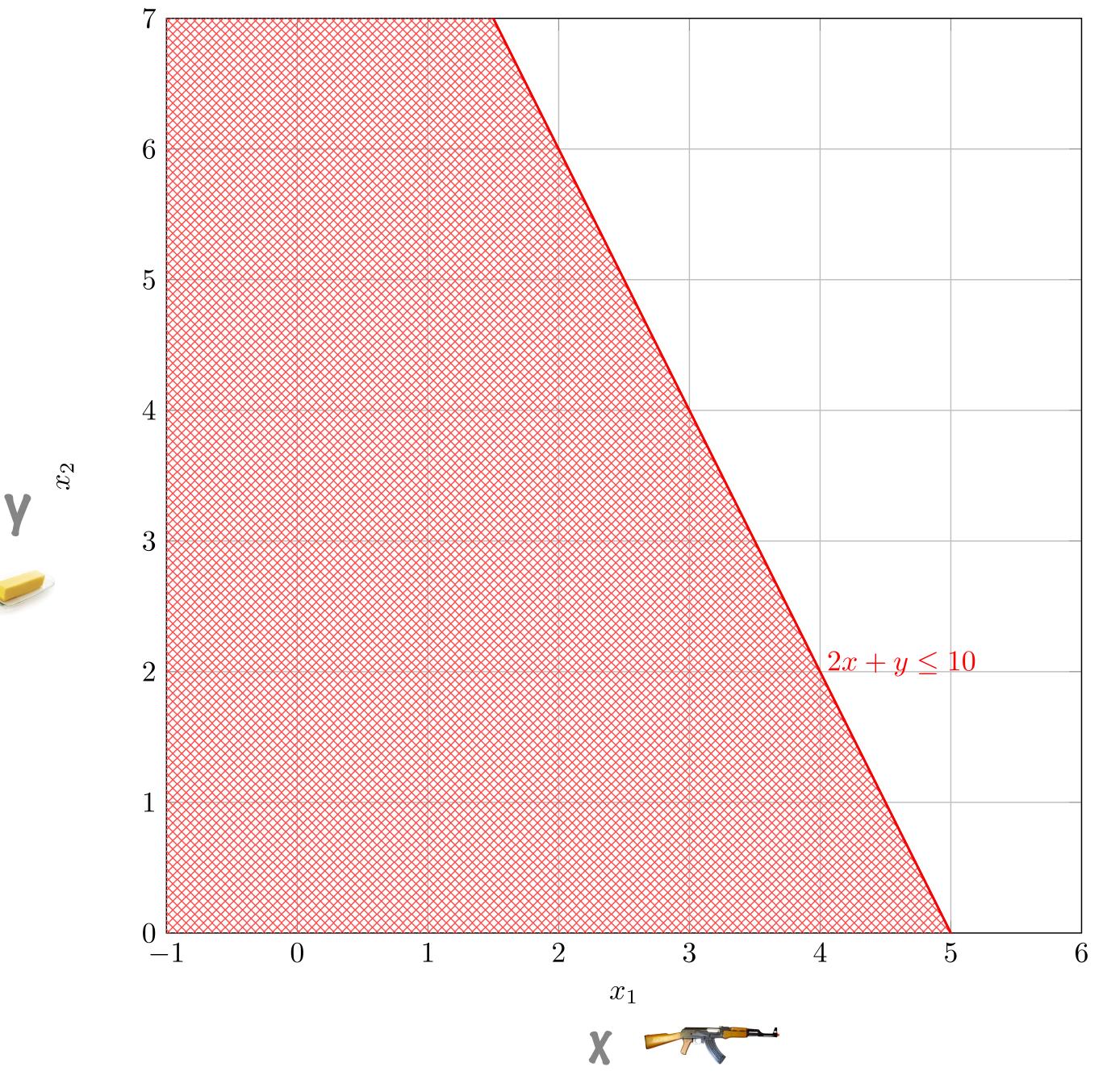


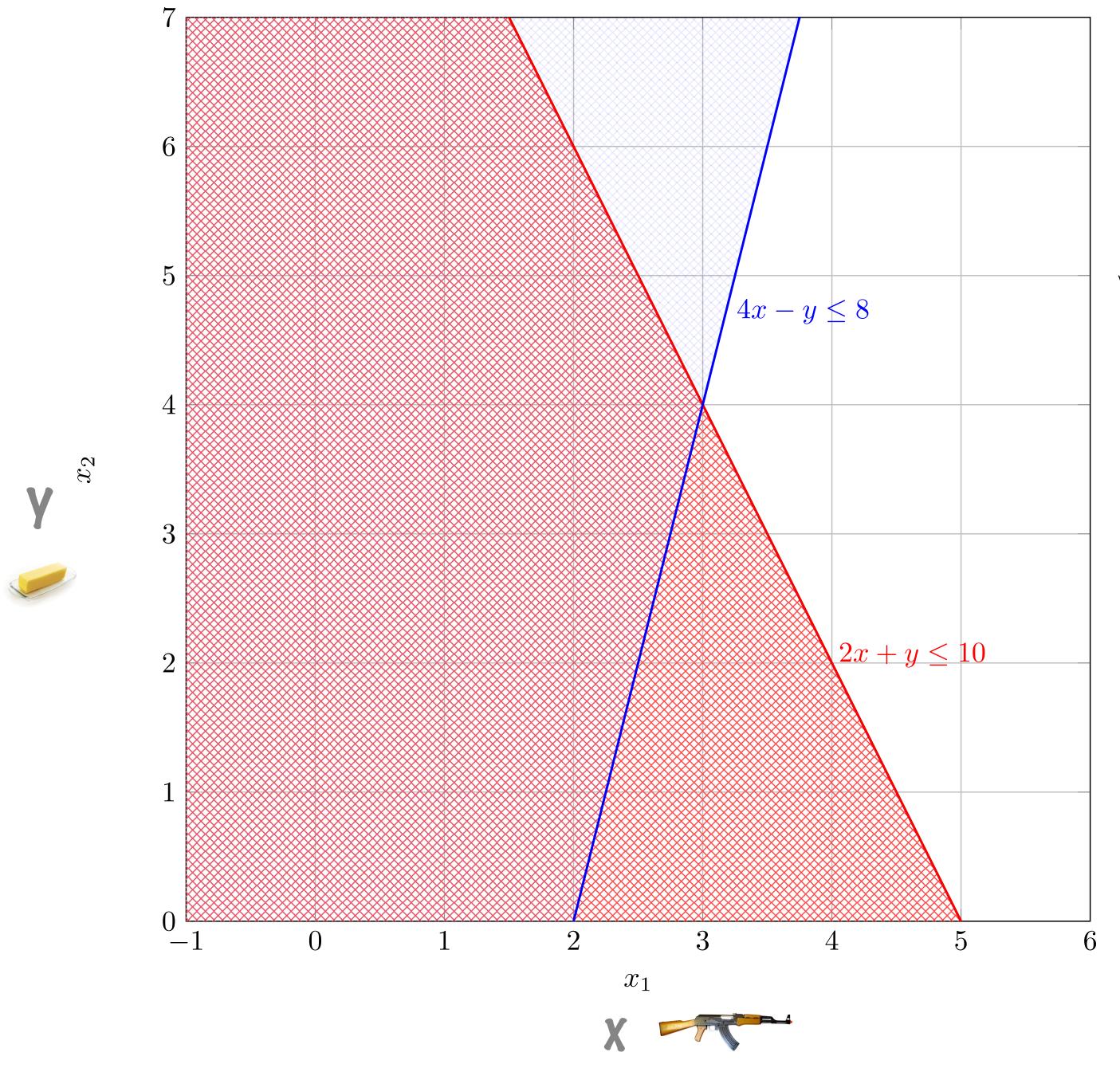




 $4x - y \leq 8$  $2x + y \leq 10$  $5x-2y \geq -2$  $x, y \geq 0$ 

 $x_1$ 



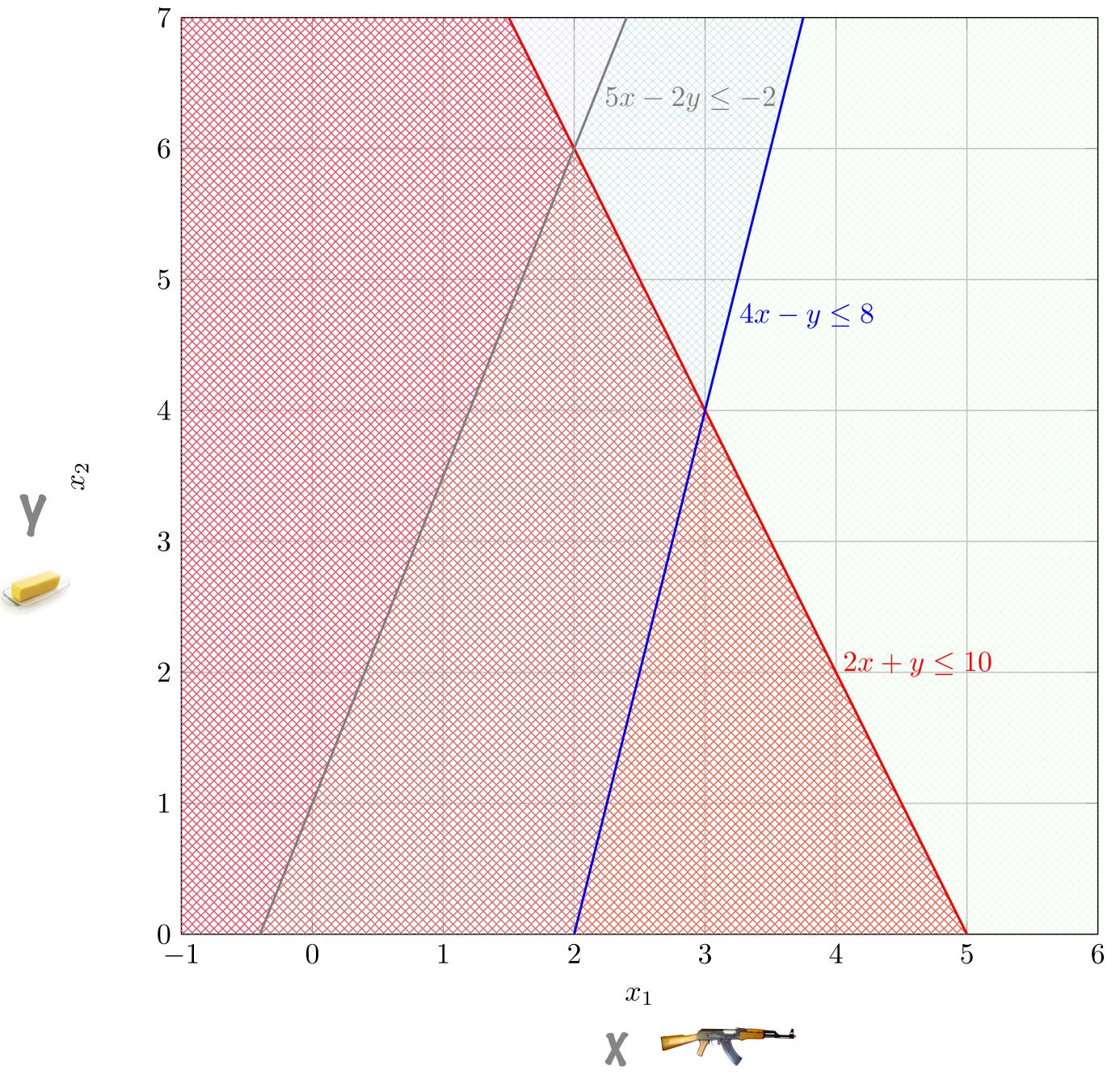


$$4x - y \leq 8$$
  

$$2x + y \leq 10$$
  

$$5x - 2y \geq -2$$
  

$$x, y \geq 0$$





 $4x - y \leq 8$  $2x + y \leq 10$  $5x-2y \geq -2$  $x, y \geq 0$ 

 $\max x + y$ 

 $4x - y \leq 8$  $2x + y \leq 10$  $5x - 2y \geq -2$  $x, y \geq 0$ 

### Certificate of optimality

 $\max x + y$ 

 $4x - y \leq 8$  $2x + y \leq 10$  $5x - 2y \geq -2$  $x, y \geq 0$ 

### Certificate of optimality

 $7 \quad 14x + 7y \le 70$  $-1 \quad -5x + 2y \le 2$  $9x + 9y \leq 72$ 



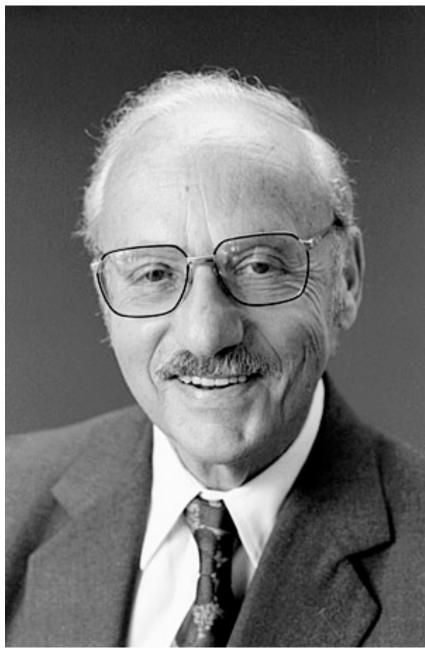


IMAGE:STAMFORD

# linear programming saved Berlin

IMAGE: HISTORY OF AIR CARGO

# Stigler diet

CALORIES	
PROTEIN	
CALCIUM	
IRON	
vitamin A	
THIAMINE	
RIBOFLAVIN	
NIACIN	
ASCORBIC ACID	

3000	
70g	
.8g	
19mg	
5000iu	
I.8mg	
2.7mg	
18mg	
75mg	

Commodity         Unit         Answer 10 (new)         Protein (new)         Calcium (gramo)         Doal (gramo)         Loss (new)         Loss (new)         Usamin (new)         A rein (new)         Asset (new)	<u></u>									· · · · · · · · · · · · · · · · · · ·				
**1. Whest Flour (Gariched) 10 [b. 36.0 12,000 44.7 1411 9.0 965 55.4 93.5 4411 8. 375 14.4 15.7 16.4 1	Commodity	Unit	1989	per \$1.00					(1,000)	Turguning	flavin		Acid	306
9. Masswori       1       16.       14.       3.217       11.6       118       .7.7       54       3.2       1.0       68         4. Wheat Creat (Rarinka       8 co.       7.1       3.144       11.4       837       1.4       175       14.4       8.3       11.4       837       1.7       3.9       10.5       1.4       8.3       11.4       837       1.7       3.9       10.5       1.4       10.5       1.6 <td< td=""><td>**]. Wheat Flour (Enriched)</td><td>10 lb.</td><td>36.0</td><td>12,600</td><td>44.7</td><td>1,411</td><td>8.0</td><td>865</td><td></td><td>35.4</td><td>55.5</td><td>441</td><td></td><td></td></td<>	**]. Wheat Flour (Enriched)	10 lb.	36.0	12,600	44.7	1,411	8.0	865		35.4	55.5	441		
6. Corn Flake       8 oz.       7.1       3.104       11.4       832       1.       56       13.5       2.3       68         6. Corn Mail       20.0.       8.4       6.61       0.50       17.4       7.9       100         6. Hoper Grite       20.0.       8.5       6.60       13.6       10.6       1.6       110         7.1       100       10.5       1.6       10.6       1.6       10.6       1.6       10.6         8. Relet Oats       116.       7.1       6.789       15.6       485       2.6       115       13.8       8.5       100         10. Whole Merat Bread (Enriched)       116.       7.9       5.748       15.0       1485       2.6       115       15.9       6.4       100         11. Rye Bread       116.       9.2       4.900       12.4       485       2.1       15.1       10.8       9.0       3.0       10.0       <	2. Macaroni			3,217	11.6	418	.7	54						
5. Corn Meal       1 lb.       4.6       9.841       35.0       897       1.7       99       30.9       17.4       7.8       105         7. Rice       1 b.       7.5       6.083       81.2       400       6.41       2.0       4.8       60         7. Rice       1 b.       7.7       6.083       81.2       400       6.41       2.0       4.8       60         9. Whice Bread       1 b.       7.7       6.048       81.2       400       6.41       2.0       4.8       60         10. Whole Wreat Bread       1 b.       9.1       4.985       12.2       4489       2.1       12.5       13.9       6.4       100         11. Ryc Bread       1 b.       9.2       4.900       13.0       -4       51       18.9       8.0       100       17       17         12. Soch Cackere       1 b.       1.1       5.006       1.47       10.8       9       2.5       4.0       10.0       10       7       170         13. Butter       1 b.       10.1       2.014       7.4       4444       19.4       9       8.1       8       10.5       4       10       10       10       10	3. Wheat Cereal (Enriched)						14.4							
6.       Homing Grita       24.or.       3.0       5.0       95.6       680       .8       90       10.6       1.6       110         7.       Rice       1b.       7.0       6.049       21.8       200       .6       41       2.0       4.8       600         8.       Rolled (Att.       1b.       7.1       6.359       25.3       207       6.1       541       97.1       8.9       64         9.       White Freed (Enriched)       1b.       7.1       6.359       25.3       207       6.1       954       25.9       8.6       100         1b.       7.1       8.20       16.4       155.0       489       2.1       155       16.8       8.5       00       16.0       16.0       16.0       16.0       16.0       16.0       16.0       16.0       16.0       16.0       16.0       16.0       16.0       16.0       17.7       177       G       177		6 oz.												
7. Rice 1 lb. 7.3 6,048 91.2 400 .6 41 2.0 4.8 00 8. Rolled Oats 1 lb. 7.9 8,748 15.6 4359 2.5 151 15 15.8 8.3 04 9. While Bread (Enriched) 1 lb. 7.9 8,748 15.6 435 2.5 115 15.8 8.3 126 10. Whole Bread (Enriched) 1 lb. 7.9 8,748 15.6 435 2.5 115 15.8 8.3 126 11. Poind Case 1 lb. 7.9 8,748 15.6 435 2.7 128 15.9 5.8 3.0 07 13. Soda Crakers 1 lb. 15.1 8,904 16.6 128 45 5 50 14. Wilk Bread (Like 1 10 10 10 10 10 10 10 10 10 10 10 10 1									\$0.9					
8. Rolled Oats       1       1b,       7.1       6.30       25.3       907       6.1       541       97.1       8.9       64         9. While Bread (Briched)       1 b,       9.1       4,985       12.2       484       2.7       12.5       13.9       6.4       100         11. Rye Bread       1 b,       9.1       4,985       12.4       484       2.7       12.5       13.9       6.4       100         11. Rye Bread       1 b,       9.4       489       1.1       52       9.9       3.0       0.0       0.0         12. Poind Cake       1 b,       9.4       489       1.1       52       0.0       10.0       7       177         13. Soft       5.0       130       -4       81       19.9       2.5       3.0       10.	7. Bior						.0							
9. White Bread (Enriched) 1 hb. 7.9 6,742 15.0 488 2.6 115 15.8 8.3 126 10. Whole Wheat Bread 1 hb. 9.1 4,985 12.2 484 2.7 125 15.9 6.4 160 11. Rye Bread 1 hb. 9.2 4,983 12.2 484 2.7 125 15.9 6.4 160 11. Rye Bread 1 hb. 9.2 4,983 12.4 489 11.1 82 9.9 8.3 0 00 11. Rye Bread 1 hb. 9.2 4,983 12.4 489 11.1 82 9.9 8.3 0 00 11. Rye Bread 1 hb. 9.2 4.8 1,840 8.0 130 4.4 131 18.9 2.8 3.0 01 11. Statement 1 hb. 15.1 5.007 11.4 182 9.0 15 00 11. Rye Bread 1 hb. 9.2 4,983 12.4 489 11.1 82 9.9 8.3 0 10.0 7 177 11. Statement 1 hb. 15.1 5.007 11.4 182 9.0 15 00 11. Rye Bread 1 hb. 9.8 4.2 1.874 71 0.8 9 2.8 3 44.2 2 2.8 2 4 2.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0		1 lb.					5.1							
10. Whole Wient Bread 1 lb. 9.1 4 085 12.2 484 2.7 125 15.9 6.4 100 11.1 Ryc Bread 1 lb. 9.2 4 0.80 12.4 485 1.1 82 9.9 3.0 00 12. Found Cake 1 lb. 24.8 1.80 8.0 130 .4 91 18.9 2.5 3.0 17 13. Sode 1 Cake 1 lb. 24.8 1.80 8.0 130 .4 91 18.9 2.5 3.0 17 13. Sode 1 Cake 1 lb. 24.8 1.80 8.0 130 .4 91 18.9 2.5 3.0 17 13. Sode 1 Cake 1 lb. 24.8 1.80 10.5 18 16.8 4.0 10.0 7 177 11. Sode 1 lb. 24.8 1.80 10.5 18 16.8 4.0 10.0 7 177 11. Sode 1 lb. 24.8 1.80 10.5 18 16.8 4.0 10.0 7 177 11. Sode 1 lb. 24.8 1.80 10.5 18 16.8 4.0 10.0 7 177 11. Sode 1 lb. 24.8 1.8 10.7 4.4 10 1.5 18 16.8 4.0 10.0 7 177 11. Sode 1 lb. 24.8 1.8 10.7 4.4 10 1.5 18 16.8 4.0 10.0 7 177 11. Sode 1 lb. 24.8 1.8 10.7 4.9 425 1.1 0 58 18.0 2.5 11 400 10.0 7 177 11. Sode 1 lb. 24.8 1.8 10.7 4.9 425 1.1 0 58 18.0 2.5 11 10.5 18 1	9. White Bread (Enriched)													
12. Found Cake 1 lb. 24.8 1,849 8.0 130 .4 81 18.9 2.8 3.0 17 13. Soda Cracketre 1 lb. 15.1 8,004 12.6 283 .5 00 14. Milk (cnn) 14 (cnn				4,985	12.2		2.7	125						
13. Soda Crackere 1 lb. 15.1 3, 004 12.6 288 1.6 30 14. Mik (m) 144 or. 6.7 6,095 8.4 422 15.1 9 20.0 3.0 25.6 11 60 7 177 16. Butter 1 lb. 50,8 1,473 10.8 9 2.8 344.2	11. Rye Bread	1 lb.					1.1					66		
14. Milk       1 qt.       11.0       8,907       6.1       310       10.5       18       16.8       4.0       10.0       7       177         15. Butter       11b.       50.6       1,475       10.8       9       2       8       44.2       .2       3       44.2       .3       4       2       3       4       4       2       3       4       4       2       3       4       4       2       3       4       4       2       3       4       2       3       4							-4		18.9	2.8	8.0	17		
**16. Evaporated Milk (can) 141 or. 6.7 6 (85 8.4 482 15.1 0 20.0 5.0 23.5 11 00 C) 16. Butter 1 B. 50.6 1.473 10.8 9 .4 8 44.5 1.0 58 44.5 .0 23.5 11 00 C) 17. Obcomargarine 1 B. 10.1 2.817 20.6 17 .6 6 55.6 .8 *17. Obcomargarine 1 B. 10.1 2.817 20.6 17 .6 6 55.6 .8 **10. Cheese (Chodar) 1 B. 24.2 1.874 7.4 444 16.4 10 28.1 8 10.5 4 **10. Cheese (Chodar) 1 B. 24.2 1.874 7.4 444 16.4 10 28.1 8 10.5 4 **10. Cheese (Chodar) 1 B. 24.2 1.874 7.4 444 16.4 10 28.1 8 10.5 4 **10. Cheese (Chodar) 1 B. 24.2 1.874 7.4 444 16.4 10 28.1 8 10.5 4 **10. Cheese (Chodar) 1 B. 25.5 2 **10. Cheese (Chodar) 1 B. 25.5 2 **10. Cheese (Chodar) 1 B. 25.5 2 **10. Cheese (Chedar) 1 B. 25.5 2 **10. Cheese (Cheese 1 B. 25.5 2 **10. Cheese 1 B 25.5 2 **10. Cheese 1 B. 25.5 2 **10. Cheese 1 B 25.5 1 **10. Cheese 1 B 45.5 1 **10. Cheese 1 B 45.7 1 **1	15. Soda Crackers								10.0		10.0	~		
16. Butter       1 b.       30.6       1 475       10.8       9       2       3       44.2       .2       2       0       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0       0       1       0 <th< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>18</td><td></td><td></td><td></td><td>.7</td><td></td><td>~</td></th<>								18				.7		~
17.       04:00       05:00       17.       6       6       55:8        0       05:00         18.       Eggs       10:5.       9:40       1.85.7       8:9       238       1.0       54       18.       8:8       0.6       1.8       10.5       4       0.0       10:5.       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       4       10:5       5       5       5       5       5       5       5       5       5       5       5       5       5       5       6       6       6       10:5       5       5       6       6       6       10:5       5       5       5       7       4       2.5       5       6       6       6       6       6       6       6       6       6       6       6       6       6	16. Butter						19.1			3.0		11	60	5
**10. Checse (Chedar) 1 hb. 24.2 1,374 7.4 448 19.4 19 28.1 8 10.5 4 C C S 17 V 19 20. Cream 4 pt. 18.1 1,399 3.5 49 1.7 3 16.9 3.6 2.5 17 V 19 21. 41.1 1,399 3.6 49 1.7 3 16.9 3.6 2.5 17 V 19 21. 41.1 1,39 3.6 18 2 9 2.7 4 5 2.6 17 1 10 48 9 2.5 17 1 10 10 10 10 10 10 10 10 10 10 10 10 1	*17. Oleomargarine						.6	ĕ		. 8				8
**10. Checse (Chedar) 1 hb. 24.2 1,374 7.4 448 19.4 19 28.1 8 10.5 4 C C S 17 V 19 20. Cream 4 pt. 18.1 1,399 3.5 49 1.7 3 16.9 3.6 2.5 17 V 19 21. 41.1 1,399 3.6 49 1.7 3 16.9 3.6 2.5 17 V 19 21. 41.1 1,39 3.6 18 2 9 2.7 4 5 2.6 17 1 10 48 9 2.5 17 1 10 10 10 10 10 10 10 10 10 10 10 10 1	18. Eggs			1,857				58			6.5	1		)R
20. Cream $\frac{1}{2}$ pt.       14.1       1,689       3.5       44       1.7       8       16.9       .6       9.6       3.1       471       47         21. PeanuButter       1       16.7       1.198       8.6       18       28       8       2.7       .4       .5       471       -4       -7         28. Crisco       16.90.3       9.284       8.6       18       28       8       2.7       .4       .5       471       -4       -4         28. Crisco       16.90.3       9.284       8.6       18       .8       8       2.7       .4       .5       6       77         28. Cluck       16.90.3       9.284       40.1       1284       9       166       1       38       2.1       2.9       69       9         29. Elect       20.7       1.683       3.4       9.13       1.33       2.0       9	**19, Cheese (Cheddar)	1 lb.		1,874	7.4			19				4		P.
22.Mayonnaise4 pt.16.71,1988.618.292.7.4.523.Crisco1 b.9.84,22840.1	20. Cream							8	16.9		2.5	_	17	
28. Crisco       1 b.       90.3       9.284 ard       1 b.       9.8       34. Lard       1 b.       9.8       48. Lard       1 b.       9.8       49. Carbo       1 th.       9.8       40. Stak       1 b.       9.8	21. Peanut Butter				15.7							471		به
24. Lard       1 b.       9.8       4.928       41.7       .8       .5       .60        .60       .60 </td <td>22. Mayonbalse</td> <td>t pt.</td> <td></td> <td>1,198</td> <td></td> <td>18</td> <td>.*</td> <td>8</td> <td>\$.7</td> <td>.4</td> <td>.5</td> <td></td> <td></td> <td></td>	22. Mayonbalse	t pt.		1,198		18	.*	8	\$.7	.4	.5			
Att, Res Note       1 m.       2 m. </td <td>ea. Crisco</td> <td>1 10.</td> <td></td> <td>4 678</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>ge</td>	ea. Crisco	1 10.		4 678										ge
Att, Res Note       1 m.       2 m. </td <td>25. Sirloin Steak</td> <td>1 16.</td> <td></td> <td>1 145</td> <td>8.9</td> <td>166</td> <td>.1</td> <td>54</td> <td></td> <td><b>R</b> 1</td> <td></td> <td></td> <td></td> <td></td>	25. Sirloin Steak	1 16.		1 145	8.9	166	.1	54		<b>R</b> 1				
Att, Res Note       1 m.       2 m. </td <td>26. Round Steak</td> <td>i ii.</td> <td></td> <td>1,246*</td> <td></td> <td></td> <td>1</td> <td></td> <td></td> <td>2.5</td> <td>8.4</td> <td>87</td> <td></td> <td>8</td>	26. Round Steak	i ii.		1,246*			1			2.5	8.4	87		8
28.Chuck Roast1 h.22.6 $2,007^{\circ}$ 3.6309.246.41.04.012012129.Plate1 h.26.8 $3,007^{\circ}$ 8.6404.262.9.9**30.Liver (Beef)1 h.26.8 $1,002^{\circ}$ $2.2$ 233.3130169.20.4 $50.5$ $316$ $525$ \$1.Log of Lamb1 h.27.6 $1,615^{\circ}$ $5.1$ 245.120 $2.6$ $3.9$ $36$ \$21.Log of Lamb1 h. $30.7$ $1,477^{\circ}$ $5.5$ 196.2 $30$ $17.4$ $2.7$ $60$ \$34.Pork Lops1 h. $30.7$ $1,477^{\circ}$ $3.5$ 196.2 $30$ $17.4$ $2.7$ $60$ \$35.Pork Loin Roast1 h. $24.6$ $1,77^{\circ}$ $3.5$ 196.2 $30$ $17.4$ $2.7$ $60$ \$35.Pork Loin Roast1 h. $25.7$ $1,477^{\circ}$ $3.5$ 196.2 $23$ $1.8$ $8.6$ $6.7$ \$36.Harm-smoked1 h. $15.0$ $2,935^{\circ}$ $18.8$ $104$ $1.20$ $1.4$ $1.8$ $3.6$ \$37.Salt Pork1 h. $10.0^{\circ}$ $2,935^{\circ}$ $18.8$ $104$ $1.20$ $1.4$ $1.8$ $3.6$ \$38.Roasting Chicken1 h. $50.5$ $1,497^{\circ}$ $1.8$ $184$ $1.30$ $1.4$ $2.4$ $57$ \$38.Roasting Chicken	27. Rib Roast	1 1Ь.		1.555			1							5
**50. Liver (Beef) 1 lb. 20.8 1,692* 2.2 353 .2 150 169.2 0.4 50.8 316 525 51. Leg of Lamb 1 lb. 27.6 1,645* 5.1 245 .1 20 2.8 3.9 86 52. Lamb Chops (Bib) 1 lb. 50.6 1,259* 3.8 140 .1 15 1.7 2.7 54 53. Pork Chops 1 lb. 30.7 1,477* 3.5 196 .2 50 17.4 2.7 54 54. Pork Loin Roast 1 lb. 25.0 1,772* 10.4 153 .2 23 1.8 1.8 71 56. Ham—smoked 1 lb. 25.0 1,772* 10.4 153 .2 23 1.8 1.8 71 57. Salt Pork 1 lb. 10.0 2.835* 18.8 104 .1 20 1.4 1.8 5.8 71 58. Roasting Chicken 1 lb. 50.3 1,497* 1.8 134 .1 20 1.4 1.4 1.8 58 53. Roasting Chicken 1 lb. 42.3 1,072* 1.7 156 .1 24 1.4 2.4 57 40. Salmon, Pink (can) 16 os. 15.0 5,489 5.8 705 6.8 47 .5 36 7.3 3.6 2.7 5 544 42. Bananas 1 lb. 4.4 9,078 5.8 705 6.8 430 17.4 2.5 3.5 28 498 41. Apples 1 lb. 4.4 9,078 5.8 77 .5 36 7.3 3.6 2.7 5 544 42. Bananas 1 lb. 4.4 9,078 5.8 705 6.8 14 30 17.4 2.5 3.5 499 41. Apples 1 lb. 4.4 9,078 5.8 705 6.8 14 30 17.4 2.5 3.5 499 41. Apples 1 lb. 4.4 9,078 5.8 705 6.8 14 30 17.4 2.5 3.5 499 41. Apples 1 lb. 4.7 9,078 5.8 705 6.8 14 30 17.4 2.5 3.5 499 41. Apples 1 lb. 4.4 9,078 5.8 705 6.8 14 30 17.4 2.5 3.5 499 41. Apples 1 lb. 4.4 9,078 5.8 705 6.8 14 30 17.4 2.5 3.5 28 498 44. Oranges 1 lb. 4.4 9,078 5.8 77 .5 36 7.3 3.6 2.7 5 544 45. Lemons 1 lb. 7.1 4,750 2.4 138 3.7 80 60,0 4.3 5.8 37 80 69.0 4.3 5.8 3	28. Chuck Roast	1 lb.	22.6	2,007*		809	. 2	46	.4			190		8
51. Leg of Lamb       1 lb.       27.6 $1,643^{\circ}$ 5.1       245       .1       20       2.8       3.9       86         58. Lamb Chops (Rib)       1 lb.       50.6 $1,439^{\circ}$ 3.8       140       .1       15       1.7       2.7       54         55. Park Chops       1 lb.       50.7 $1,477^{\circ}$ 3.5       198       .2       30       17.4       2.7       60         54. Pork Loin Roast       1 lb.       26.4 $1,874^{\circ}$ 4.4       240       .8       37       18.2       3.0       70         56. Bacon       1 lb.       27.4       10.4       152       .2       23       1.8       1.8       1.8       71         56. Ham—smoked       1 lb.       16.0       2.855^{\circ}       18.8       104       .1       20       1.4       1.5         57. Sait Pork       1 lb.       40.3       1.477^{\circ}       1.8       184       .1       30       .1       9       1.8       68       46         58. Rossting Chicken       1 lb.       42.3       1.477^{\circ}       1.8       184       .1       30       .1       9       1.8       68       46	29. Plate	1 Ць.		3,107*		404	.2							
58. Lamb Chops (Rib)1 lb.36.61, $439^{\circ}$ 3.8140.1151.72.75453. Pork Chops1 lb.30.71, $477^{\circ}$ 3.5196.23017.42.76054. Pork Loin Roast1 lb.84.21, $874^{\circ}$ 4.4840.53718.23.07085. Bacon1 lb.25.01, $772^{\circ}$ 10.4158.2231.81.87156. Ham—smoked1 lb.27.41, $655^{\circ}$ 6.7212.2319.93.55037. Salt Pork1 lb.16.02, $835^{\circ}$ 18.8104.1201.41.538. Rosating Chicken1 lb.50.31, $497^{\circ}$ 1.8194.130.1.91.86840. Salmon, Pink (cam)16 oz,15.03, 4805.87056.8453.51.04.920941. Apples1 lb.6.14, 99824.960.43017.42.5554442. Bananas1 lb.6.14, 9892.2401.11811.15.61.5101, 99843. Lemons1 doz.30.94, 4392.2401.11811.15.61.5101, 99844. Oranges1 doz.30.92.41385.78069.04.55.8378069.04.55.8 </td <td>S0. Liver (Beet)</td> <td>145.</td> <td></td> <td>1,698*</td> <td></td> <td></td> <td></td> <td></td> <td>169.9</td> <td></td> <td></td> <td></td> <td>585</td> <td></td>	S0. Liver (Beet)	145.		1,698*					169.9				585	
55. Pork Chops1 lb.30.71,477*3.5196.23017.42.76034. Pork Loin Roast1 lb. $24.2$ 1,874*4.4 $240$ .33718.23.67035. Bacon1 lb. $25.6$ 1,772*10.4158.22318.83.67156. Ham-smoked1 lb. $27.4$ 1,655*6.7 $212$ .2319.93.35037. Salt Pork1 lb.16.0 $2.835*$ 18.8104.1201.41.838. Roasting Chicken1 lb. $40.3$ $3.97*$ 1.8184.130.1.91.86839. Veal Cutlets1 lb. $40.3$ $3.97*$ 1.8184.130.1.91.8684639. Veal Cutlets1 lb. $42.3$ $1.072*$ 1.7156.1 $24$ 1.4 $2.4$ $57$ 40. Salmon, Pink (can)16 os.15.0 $3.489$ $5.8$ $705$ $6.8$ $45$ $3.5$ $1.0$ $4.9$ $209$ 41. Apples1 lb. $4.4$ $9.978$ $5.8$ $87$ $.5$ $36$ $7.3$ $3.6$ $2.7$ $5$ $544$ 42. Bananas1 lb. $4.1$ $9.992$ $4.5$ $3.5$ $2.8$ $498$ 43. Lemons1 doz. $30.9$ $4.836$ $2.2$ $40$ $1.1$ $18$ $11.1$ $5.8$ $1.5$ $6.44$ 44. Oranges1 do	SI. Leg of Lamb	1 10.		1,633*										
34. Pork Loin Ronst1 lb. $24.2$ $1,874^{\circ}$ $4.4$ $240$ $.3$ $37$ $18.2$ $3.6$ $79$ 85. Bacon1 lb. $25.0$ $1,772^{\circ}$ $10.4$ $153$ $.2$ $23$ $1.8$ $1.8$ $71$ 56. Ham—smoked1 lb. $27.4$ $1,655^{\circ}$ $6.7$ $912$ $.2$ $23$ $1.8$ $1.8$ $71$ 57. Salt Pork1 lb. $10.0$ $2,835^{\circ}$ $18.8$ $104$ $120$ $1.4$ $1.8$ 35. Roasting Chicken1 lb. $50.3$ $1,497^{\circ}$ $1.8$ $184$ $1$ $30$ $.1$ $.9$ $1.3$ $68$ $46$ 39. Veal Cutlets1 lb. $42.3$ $1,072^{\circ}$ $1.7$ $156$ $.1$ $24$ $1.4$ $2.4$ $57$ 40. Salmon, Pink (can)16 oz. $13.0$ $3,489$ $5.8$ $705$ $6.6$ $45$ $5.5$ $1.0$ $4.9$ $209$ 41. Apples1 lb. $6.1$ $4,982$ $4.9$ $60$ $.4$ $30$ $17.4$ $2.5$ $3.5$ $28$ $498$ 43. Lemons1 doz. $80.0$ $2,380$ $1.0$ $21$ $.6$ $14$ $.5$ $4$ $662$ 44. Oranges1 doz. $30.9$ $4,439$ $2.2$ $40$ $1.1$ $18$ $11.1$ $5.6$ $1.5$ $10$ $1,998$ $45.$ Green Beans1 lb. $3.7$ $8,949$ $2.6$ $125$ $4.0$ $36$ $7.2$ $9.0$ $4.5$ $26$ $5,369$	58. Park Chops (Rib)	116		1,477*			.5							
85. Bacon1 lb.25.6 $1,772^*$ 10.4158.2231.81.81.67156. Ham—smoked1 lb.27.51,655*6.7212.6319.93.55057. Salt Pork1 lb.16.02,855*18.8164.1201.41.538. Rosting Chicken1 lb.42.31,97*1.8194.130.1.91.859. Veal Cutlets1 lb.42.31,072*1.7156.1241.42.45740. Salmon, Pink (can)16 oz.13.05,8395.87056.6455.51.04.920941. Apples1 lb.6.14,9824.960.43017.42.53.52849345. Lemons1 doz.26.02,3801.021.614.5465244. Oranges1 doz.30.94,4392.2401.11811.13.61.5101.998*45. Gene Beans1 bb.7.15,7502.41383.78069.04.35.837862**46. Cabbage1 bb.3.78,9492.61254.0567.29.04.5265,369**46. Cabbage1 bb.3.78,9492.61254.0567.29.04.5265,369**46. Cabbage1 bb. <t< td=""><td>S4. Pork Loin Roast</td><td>i 16.</td><td></td><td>1.874</td><td></td><td></td><td></td><td>37</td><td></td><td>18.8</td><td>3.6</td><td>70</td><td></td><td></td></t<>	S4. Pork Loin Roast	i 16.		1.874				37		18.8	3.6	70		
56. Ham—smoked1 lb. $27.4$ 1,655* $6.7$ $212$ .8 $31$ $9.9$ $3.3$ $50$ 37. Salt Park1 lb.16.0 $2,855*$ $18.8$ $104$ .1 $20$ $1.4$ $1.8$ 38. Reasting Chicken1 lb. $42.3$ $1,497*$ $1.8$ $184$ .1 $30$ .1.9 $1.8$ $68$ $46$ 39. Veal Culleta1 lb. $42.3$ $1,072*$ $1.7$ $156$ .1 $24$ $1.4$ $2.4$ $57$ 40. Salmon, Pink (can)16 oz. $13.0$ $3,480$ $5.8$ $705$ $6.6$ $45$ $5.5$ $1.0$ $4.9$ $209$ 41. Apples1 lb. $4.4$ $9,078$ $5.8$ $87$ $.5$ $56$ $7.5$ $3.6$ $2.7$ $5$ $544$ 42. Bananas1 lb. $6.1$ $4,982$ $4.9$ $60$ $.4$ $50$ $17.4$ $2.5$ $3.5$ $28$ $498$ 45. Lemons1 doz. $30.9$ $4,439$ $2.2$ $40$ $1.1$ $18$ $11.1$ $5.6$ $1.5$ $10$ $1.998$ *45. Green Beans1 lb. $7.1$ $5,750$ $2.4$ $138$ $3.7$ $80$ $69.0$ $4.3$ $5.8$ $37$ $862$ **46. Cabbage1 lb. $3.7$ $8,949$ $2.6$ $125$ $4.0$ $56$ $7.2$ $9.0$ $4.5$ $26$ $5,849$ *45. Green Beans1 lb. $3.7$ $8,949$ $2.6$ $125$ $4.0$ $56$ $7.2$ $9.0$	<ol> <li>Bacon</li> </ol>	i ib.		1.772*		158	.2					71		
38. Rossting Chicken1 lb. $$0.3$ $1,497^{\bullet}$ $1.8$ $184$ $.1$ $30$ $.1$ $.9$ $1.8$ $68$ $46$ 39. Veal Cutlets1 lb. $42.3$ $1,072^{\bullet}$ $1.7$ $156$ $.1$ $24$ $1.4$ $2.4$ $87$ 40. Salmon, Pink (can)16 oz. $15.0$ $3,439$ $5.8$ $705$ $6.8$ $45$ $5.5$ $1.0$ $4.9$ $209$ 41. Apples1 lb. $4.4$ $9,078$ $5.8$ $87$ $.5$ $36$ $7.3$ $3.6$ $2.7$ $5$ $544$ 42. Bananaa1 lb. $6.1$ $4,982$ $4.9$ $60$ $.4$ $30$ $17.4$ $2.5$ $3.5$ $28$ $498$ 43. Lemons1 doz. $26.0$ $2,380$ $1.0$ $21$ $.5$ $14$ $.5$ $4$ $658$ 44. Oranges1 doz. $30.9$ $4,439$ $2.2$ $400$ $1.1$ $18$ $11.1$ $5.6$ $1.5$ $10$ $1,998$ *45. Green Beans1 lb. $7.1$ $5,750$ $2.4$ $138$ $3.7$ $80$ $69.0$ $4.3$ $5.8$ $37$ $868$ **46. Cabbage1 lb. $3.7$ $8,949$ $2.6$ $125$ $4.0$ $36$ $7.2$ $9.0$ $4.5$ $26$ $5,369$ *47. Carrots1 bunch $4.7$ $6,080$ $2.7$ $75$ $9.8$ $43$ $188.5$ $6.1$ $4.3$ $89$ $608$ *46. Cabrage1 bunch $4.7$ $6,080$ $2.7$ $75$	<ol> <li>Ham—smoked</li> </ol>	1 Jb.		1,655*		212	. 8			9.9		50		
39. Veal Cutlets1 lb.42.3 $1,072^*$ $1.7$ $156$ $.1$ $24$ $1.4$ $2.4$ $57$ 40. Salmon, Pink (can)16 oz. $15.0$ $3,489$ $5.8$ $705$ $6.8$ $45$ $3.5$ $1.0$ $4.9$ $209$ 41. Apples1 lb. $4.4$ $9,078$ $5.8$ $87$ $.5$ $36$ $7.5$ $3.6$ $2.7$ $5$ $544$ 42. Bananas1 lb. $6.1$ $4,982$ $4.9$ $60$ $.4$ $30$ $17.4$ $2.5$ $3.5$ $28$ $498$ 43. Lemons1 doz. $26.0$ $2,380$ $1.0$ $21$ $.6$ $14$ $.5$ $4$ $952$ 44. Oranges1 doz. $30.9$ $4,439$ $2.2$ $40$ $1.1$ $18$ $11.1$ $3.6$ $1.5$ $10$ $1,998$ *45. Green Beans1 b. $7.1$ $5,750$ $2.4$ $138$ $3.7$ $80$ $69.0$ $4.3$ $5.8$ $37$ $868$ **46. Cabbage1 b. $3.7$ $8,949$ $2.6$ $135$ $4.0$ $56$ $7.2$ $9.0$ $4.3$ $5.8$ $37$ $866$ 47. Carrots1 bunch $4.7$ $6,050$ $2.7$ $75$ $8.8$ $43$ $188.5$ $6.1$ $4.3$ $89$ $608$ 49. Lettuce1 banch $4.7$ $6,050$ $2.7$ $75$ $8.8$ $43$ $188.5$ $6.1$ $4.3$ $89$ $608$	<ol> <li>Salt Pork</li> </ol>	1 lb.		2,835*			.1	26		1.4				
40. Salmon, Pink (can)16 oz.15.03,4895.87056.8455.51.04.920941. Apples1 lb.4.49,0785.8 $\$7$ .5567.33.6 $$2,7$ 554442. Bananaa1 lb.6.14,9824.960.43017.4 $$2,5$ $$3,5$ 2849845. Lemons1 dox.86.0 $$2,380$ 1.0 $$21$ .514.5496844. Oranges1 dox.30.94,439 $$2.2$ 401.11811.15.61.5101,998*46. Green Beans1 lb.7.1 $$750$ $$2.4$ 138 $$3.7$ 8069.04.35.837868**46. Cabbage1 lb.3.7 $$949$ $$2.6$ 1254.0567.29.04.5265,36947. Carrots1 busch4.76,050 $$2.7$ 75 $$8.8$ 43188.56.14.38960848. Celery1 stalk7.3 $$915$ .9513.0 $$23$ .91.41.49\$1349. Lettuce1 head $$8.2$ $$2,477$ .4 $$27$ 1.1 $$22$ 112.41.83.411 $$449$	<ol> <li>Roasting Chicken</li> </ol>	1 њ.					.1		.1				46	
41. Apples1 lb.4.49,0785.8 $\$7$ .5367.33.6 $\pounds,7$ 554442. Bananas1 lb.6.14,9824.960.43017.4 $\pounds,5$ 3.5 $\pounds8$ 49843. Lemons1 doz. $\pounds6.0$ $\pounds,380$ 1.0 $\pounds1$ .514.5495244. Oranges1 doz. $30.9$ $4,439$ $\pounds,22$ 401.11811.15.61.5101,998*45. Green Beans1 lb.7.1 $\delta,750$ $\pounds,4$ 138 $3.7$ 8069.0 $4.3$ $5.8$ 37862**46. Cabbage1 lb.3.7 $\$,949$ $\pounds.6$ 125 $4.0$ 36 $7.2$ $9.0$ $4.5$ $26$ $5,369$ 47. Carrots1 bunch $4.7$ $6,080$ $\pounds.7$ $73$ $\$,8$ $43$ 188.5 $6.1$ $4.3$ 8960848. Celery1 stalk $7.3$ $3,915$ $.9$ $51$ $3.0$ $\pounds3$ $.9$ $1.4$ $1.4$ $9$ $$13$ 49. Lettuce1 head $8.2$ $2,247$ $.4$ $27$ $1.1$ $22$ $112.4$ $1.8$ $3.4$ $11$ $449$	59. Veal Cutlets			1,072*			a.1							
42. Bananas1 lb.6.14,9824.960.43017.42.53.52849843. Lemons1 doz.26.02,3801.021.514.5495244. Oranges1 doz.30.94,4392.2401.11811.15.61.5101,998*45. Green Beans1 lb.7.15,7502.41383.78069.04.35.837862**46. Cabbage1 lb.3.78,9492.61254.0367.29.04.5265,36947. Carrots1 bunch4.76,0802.7739.843188.56.14.38960848. Celery1 stalk7.33,915.9513.023.91.41.4931349. Lettuce1 head8.22,247.4271.122112.41.83.411449	41. Apples			9,459					3.5	1.0		202	544	
43. Lemons1 dor. $26.0$ $2,380$ $1.0$ $21$ $.5$ $14$ $.5$ $4$ $952$ 44. Oranges1 dor. $30.9$ $4,439$ $2.2$ $40$ $1.1$ $18$ $11.1$ $5.6$ $1.5$ $10$ $1,998$ *45. Green Beans1 lb. $7.1$ $5,750$ $2.4$ $138$ $3.7$ $80$ $69.0$ $4.3$ $5.8$ $37$ $862$ **46. Cabbage1 lb. $3.7$ $8,949$ $2.6$ $125$ $4.0$ $36$ $7.2$ $9.0$ $4.5$ $26$ $5,369$ $47.$ Carrots1 bunch $4.7$ $6,080$ $2.7$ $73$ $9.8$ $43$ $188.5$ $6.1$ $4.3$ $89$ $608$ $48.$ Celery1 stalk $7.3$ $3,915$ $.9$ $51$ $3.0$ $23$ $.9$ $1.4$ $1.4$ $9$ $$13$ $49.$ Lettuce1 head $8.2$ $2,247$ $.4$ $27$ $1.1$ $22$ $112.4$ $1.8$ $3.4$ $11$ $449$	42. Bananas	1 16.		4,089						9.5		48		
44. Oranges       1 dor.       30.9       4,439       2.2       40       1.1       18       11.1       5.6       1.5       10       1,998         *45. Green Beans       1 lb.       7.1       5,750       2.4       138       3.7       80       69.0       4.3       5.8       37       862         **46. Cabbage       1 lb.       3.7       8,949       2.6       125       4.0       36       7.2       9.0       4.5       26       5,369         47. Carrots       1 bunch       4.7       6,080       2.7       73       9.8       43       188.5       6.1       4.3       89       608         48. Celery       1 stalk       7.3       3,915       .9       51       3.0       33       .0       1.4       1.4       9       \$13         49. Lettuce       1 head       8.2       2,247       .4       27       1.1       22       112.4       1.8       3.4       11       449				2,380		81					414			
*45. Green Beans       1 lb.       7.1       5,750       2.4       138       3.7       80       69.0       4.3       5.8       37       862         **46. Cabbage       1 lb.       3.7       8,949       2.6       125       4.0       36       7.2       9.0       4.5       26       5,369         47. Carrots       1 bunch       4.7       6,090       2.7       75       9.8       43       188.5       6.1       4.3       89       608         48. Celery       1 stalk       7.3       3,915       .9       51       3.0       23       .9       1.4       1.4       9       913         49. Lettuce       1 head       8.2       2,247       .4       27       1.1       22       112.4       1.8       3.4       11       449	44. Oranges	1 dox.		4,439	2.2	40	1.1	18			1.5	10		
47. Carrots 1 bunch 4.7 6,080 2.7 75 9.8 45 188.5 6.1 4.3 89 608 48. Celery 1 stalk 7.3 3,915 .9 51 3.0 23 .9 1.4 1.4 9 813 49. Lettuce 1 head 3.2 2,247 .4 27 1.1 22 112.4 1.8 3.4 11 449	*45, Green Beans		7.1	5,750	2.4	138	5.7		69.0	4.3	5.8	37	868	
48. Celery 1 stalk 7.8 3,915 .9 51 3.0 93 .9 1.4 1.4 9 813 49. Lettuce 1 head 3.2 2,247 .4 27 1.1 22 112.4 1.8 3.4 11 449	**46. Cabbage	1 lb.	3.7	8,949	2.6	125		36	7.2	9.0		26	5,369	
49. Lettuce 1 head 8.2 2,247 .4 27 1.1 22 112.4 1.8 3.4 11 449	47. Carrots	I bunch	4.7	6,080	-		3.0			6.1	9.9	89	608	
*50. Onions 11b. 5.6 11,844 5.8 166 5.8 59 16.6 4.7 5.9 21 1,184	48. Celery 49. Lettrus	1 stalk		3,915		51	5.0					.9	813	
	*50. Objeta			11 844			1.1		16.6	1.9		41	1 194	
		1 10.	0.0	11,000	010	100	010		1010		<b>V</b> . W		.,	

### TABLE A. NUTRITIVE VALUES OF COMMON FOODS PER DOLLAR OF EXPENDITURE, AUGUST 15, 1989

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	Potatora	15 lb.	84.0	18,810	14.8	336	1.8	118	6.7	29.4	7.1	198	2,522
	Spinach	1 lb.	8.1	4,59%	1.1	106		138	918.4	5.7	13.8	55	2,755
	Sweet Potatoes	1 lb.	5.1	7,649	9.6	198	2.7	54	290.7	8.4	5.4	85	1,914
54.		No. 21	16.8	4,894	3.7	20 8	- 4	10	21.5	.5	1.0	81	196
	Pears (can)	No. 2	20.4	4,050	5.0	8	. 5	8	.8	.8	.8	5	81
56.		No. 2	21.5	3,995	2.4	16 53 54	.4	8	2.0	2.8	.8	7	399
47.	Asparagus (can)	No. 2	27.7	1,945	1.0	\$3	.5	18	16.3	1.4	2.1	17	272
	Green Beans (can)	No. 2	10.0	5,386	1.0	54	2.0	6.5	58.9	1.6	4.3	38	451
59.		16 oz.	7.1	6,889	7.5	564	4.0	154	\$.5	8.5	7.7	56	
60.	Corn (can)	No. 2	10.4	5,45%	5.8	136	. 2	16	12.0	1.6	2.7	42	\$18
	Peas (can)	No. 2	13.8	4,109	2.3	156	.6	45 58	\$4.9	4.9	2.5	37	\$70
62.	the second se	No. 2	8.6	6,263	1.5	63	.7	38	55.2	8.4	8.5	36	1,258
63.	Tomato Soup (can)	104 oz.	7.6	8,917	1.6	71	.6	45	57.9	8.5	2.4	67	862
*64.	Peaches, Dried	1 16.	15.7	2,889	8.5	71 87	1.7	175	86.8	1.8	4.3	55	57
*65.		1 16.	9.0	4,284	12.8	99	2.5	154	85.7	5.9	4.3	55 65	257
68,	Raisins, Dried	15 oz.	9.4	4,524	15.5	104	2.5	136	4.5	6.5	1.4	24	156
67.	Peas, Dried	1 lb.	7.9	5,748	20.0	1,967	4.2	845	8.9	28.7	18.4	168	200
**68.	Lima Beans, Dried	î lb.	8.9	5,097	17.4	1,055	5.7	459	5.1	\$6.9	58.2	98	
**69.	Navy Beans, Dried	1 Њ.	5.9	7,688	26.9	1,691	11.4	792		38.4	24.6	817	
70.	Coffee	1 lb.	22.4	2,025				-		4.0	5.1	50	
71.		t lb.	17.4	658		_		_		3.0	8.3	50 48	
72.		Soz.	8.6	2,657	8.7	237	3.0	72		8.0	11.9	40	
	Chocolate	Soz.	16.2	1,400	8.0	77	1.3	39		.9	3.4	40	
76	Sugar	10 lb.	51.7	8,773	54.9		110				0.4	.,	
75	Corn Sirup	34 oz.	18.7	4,968	14.7		.5	74					
76	Molamen	18 oz.	13.6	5,758	9.0		10.3	844		1.9	7.5	146	
77.		1 lb.	20.5	2,213	6.4	11	.4	2.44	.2	.2	.4	3	
	Science of the state of the sta	1 10.	10.0	E, 510	0.3							<i>°</i>	

Quantities including inedible portions.

Commodity	Price Aug. 15, 1944 (cents)	Calories (1,000)	Protein (grams)	Caleium (grams)	Iron (mg.)	Vitamin A (1,000 I.U.)	Thiamine (mg.)	Riboflavin (mg.)	Niscin (mg.)	Ascorbic Acid (mg.)
1. Wheat Flour	64.6	24.9	786	1.1	203		30.9	18.6	246	
<ol><li>Wheat Cereal</li></ol>	23.2	12.5	398	15.0	203 183		15.0	9.8	119	
5. Corn Meal	6.5	26.9	655	1.2	72	22.6	12.7		77	
8. Rolled Oats	9.9	18.1	651	5.7	245		25.5	5.8 6.4	46	
15. Evaporated Milk	10.0	5.6	283	10.1	6	17.4	2.0	15.7	7	40
<ol> <li>Cabbage</li> </ol>	4.9	2.0 6.1	94	8.0	27	5.4	6.8	3.4	*0	4,054 1,071 1,924 798
51. Potators	80.1	6.1	145	.8	50 96	2.8	12.5	3.0	20 84	1,071
58. Spinach	11.6	.8	74	-	96	641.5		9.6	25 54	1,984
53. Sweet Potatoes	12.5	4.0	57	1.1	22	120.5	4.0	2.2	34	798
69. Navy Beans	10.8	14.7	924	6.2	458		21.0	18.4	119	
74. Sugar	67.0	26.9								
78. Pancake Flour <sup>4</sup>	18.8	16.0	479	18.1	46		8.7	1.9	41	
79. Beets <sup>3</sup>	7.8	2.2	85	1.1	46 70	152.5	3.7 2.9	1.9	41 29	895
80. Liver (Pork) <sup>a</sup>	\$1.9	8.7	408	.2	518	145.0	10.4	51.8	472	580

<sup>1</sup> Unit: 90 oz.; edible weight: 4,647 g.

\* Unit: 1 bunch; edible weight: 4,971 g. Unit: 1 lb.; edible weight: 2,071 g.

### TABLE B. NUTRITIVE VALUES OF COMMON FOODS PER DOLLAR OF EXPENDITURE, AUGUST 15, 1944

THE COST OF SUBBISTENCE

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	Brownie	Dumpling	Espresso	Amelia
cost	5	2	3	8
cals	400	200	150	500
choc	3	2	0	0
sugar	2	2	4	4
fat	2	4	0	5

requirements:

500 calories, 6 oz choc, 10 oz sugar, 8 oz fat

	Brownie	Dumpling	Espresso	Amelia
cost	5	2	3	8
cals	400	200	150	500
choc	3	2	0	0
sugar	2	2	4	4
fat	2	4	0	5

requirements:

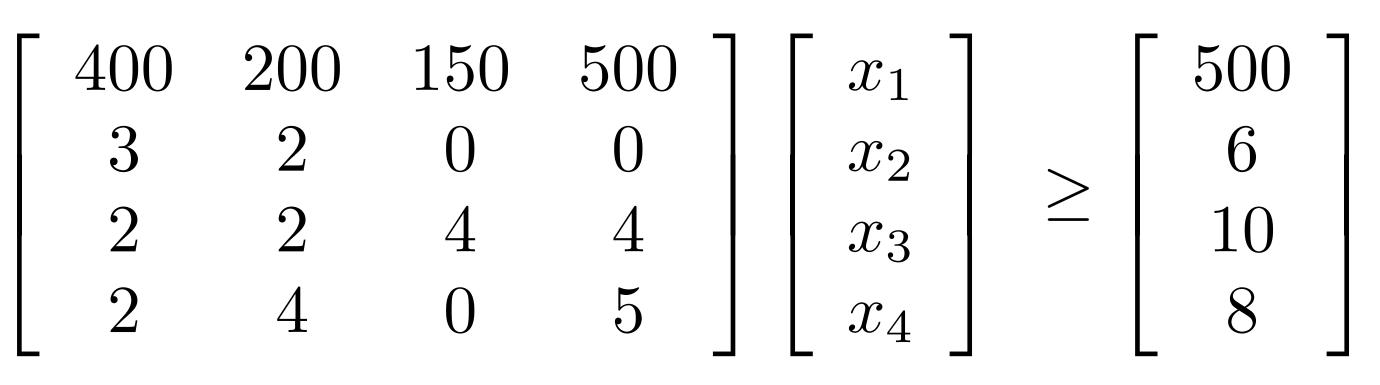
500 calories, 6 oz choc, 10 oz sugar, 8 oz fat

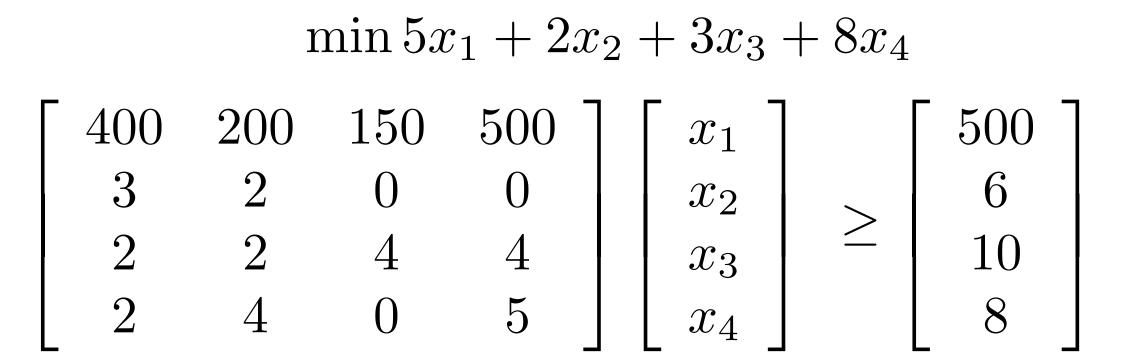
	Brownie	Dumpling	Espresso	Amelia
cost	5	2	3	8
cals	400	200	150	500
choc	3	2	0	0
sugar	2	2	4	4
fat	2	4	0	5

requirements:

500 calories, 6 oz choc, 10 oz sugar, 8 oz fat

 $\min 5x_1 + 2x_2 + 3x_3 + 8x_4$ 



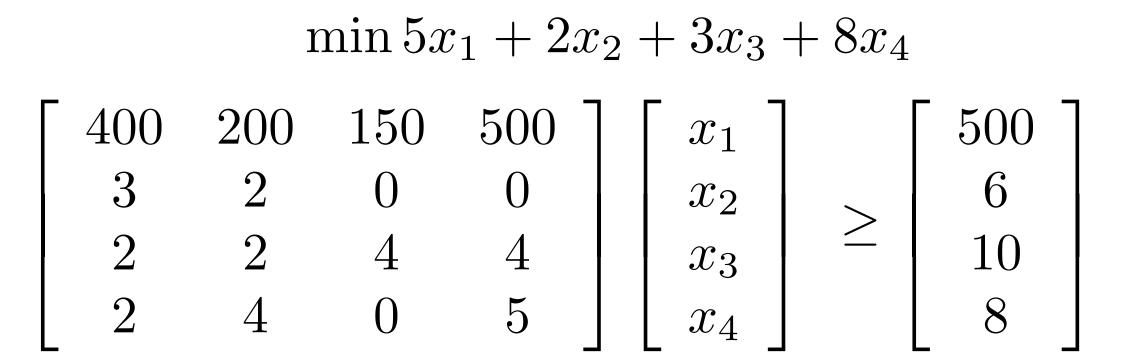


## $\min 5x_1$

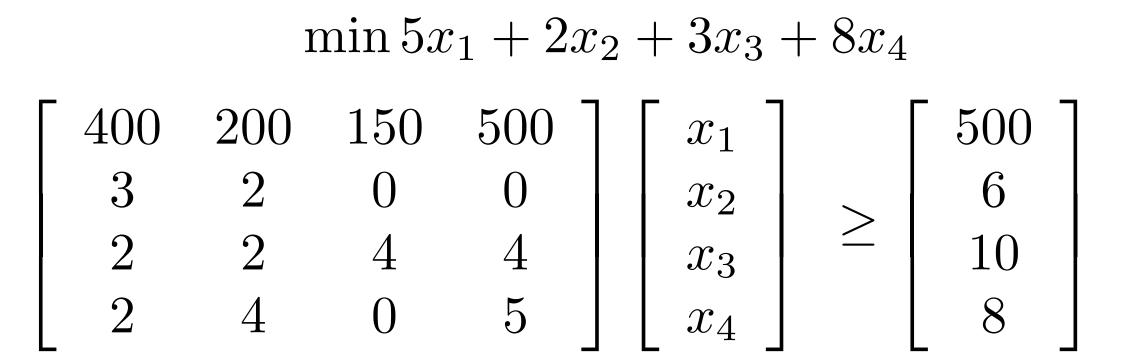
400	200	150
3	2	0
2	2	4
2	4	0
-		

$$\begin{bmatrix} +2x_{2} + 3x_{3} + 8x_{4} \\ 500 \\ 0 \\ 4 \\ 5 \end{bmatrix} \begin{bmatrix} x_{1} \\ x_{2} \\ x_{3} \\ x_{4} \end{bmatrix} \ge \begin{bmatrix} 500 \\ 6 \\ 10 \\ 8 \end{bmatrix}$$

150	500
0	0
4	4
0	5
0	0
0	0
1	0
0	1
	0 4 0 0 0 1



H-representation					
begi	begin				
84	ratio	onal			
-500	400	200	150	500	
-6	3	2	0	0	
-10	2	2	4	4	
-6	2	4	0	5	
0	1	0	0	0	
0	0	1	0	0	
0	0	0	1	0	
0	0	0	0	1	
end					
minimize					
0 5 2 3 8					



## $\min 5x_1$

400	200	150
3	2	0
2	2	4
2	4	0

\*Objective function is begin primal\_solution 0 1: 2:3 3:1 0 4 : dual\_solution 2: -1/45: -11/43 : -3/4 -5 8: optimal\_value : 9 end

```
H-representation
begin
8 4 rational
-500 400 200 150 500
-6
            0
    3
        2
                 0
    2 2
-10
           4
            0
                 5
        4
-6
    2
                 0
    1
        0 0
0
    0
0
0
        1
            0
                 0
            1
                 0
        0
0
     0
                 1
0
            0
        0
end
minimize
0 5 2 3 8
```

$$\begin{array}{c} +2x_{2} + 3x_{3} + 8x_{4} \\ 500 \\ 0 \\ 4 \\ 5 \end{array} \left[ \begin{array}{c} x_{1} \\ x_{2} \\ x_{3} \\ x_{4} \end{array} \right] \geq \left[ \begin{array}{c} 500 \\ 6 \\ 10 \\ 8 \end{array} \right]$$

```
0 + 5 X[1] + 2 X[2] + 3 X[3] + 8 X[4]
*LP status: a dual pair (x, y) of optimal solutions found.
```

\*number of pivot operations = 4

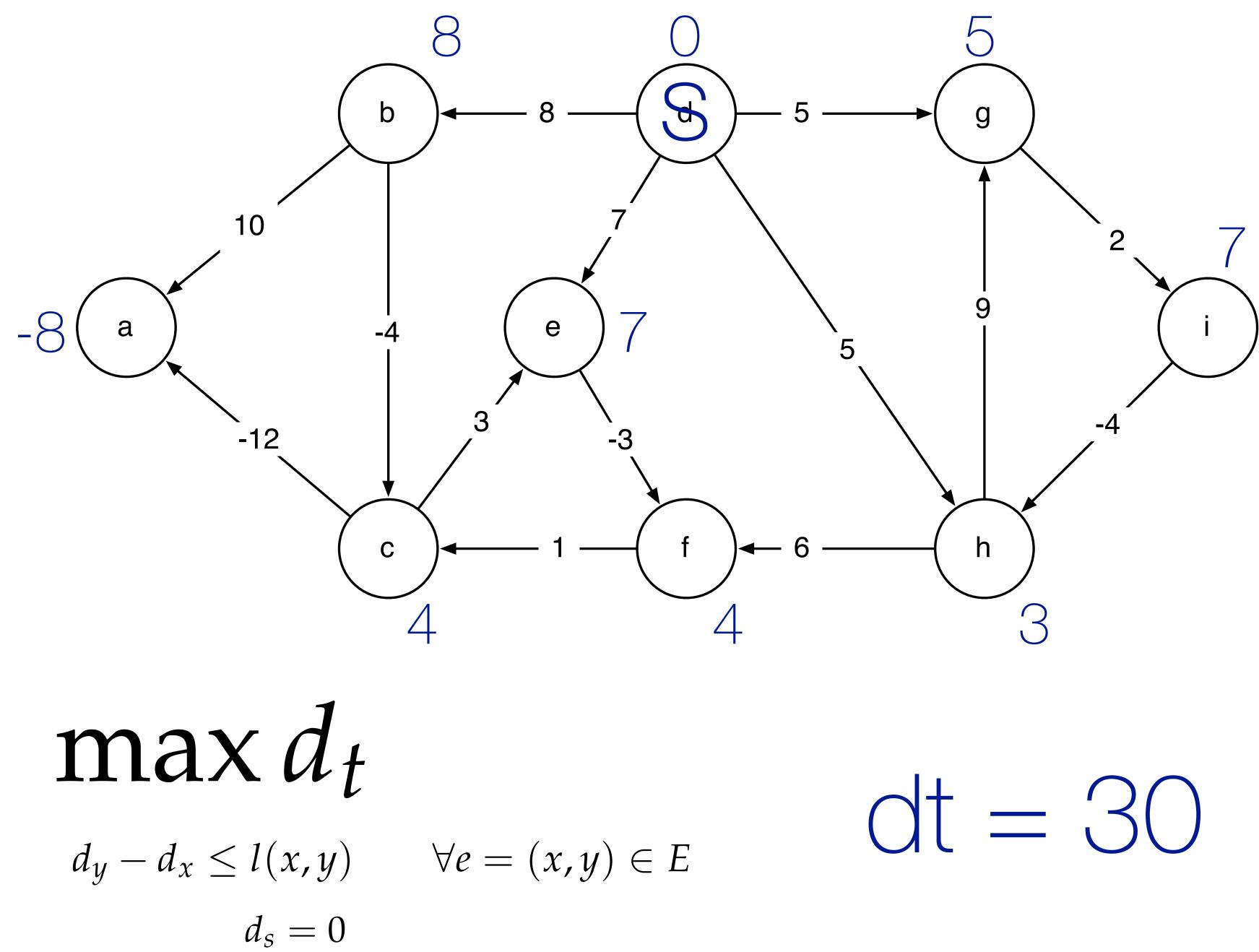
# shortest paths as LP

## inputs:

## shortest paths as LP

 $d_y - d_x \le l(x, y) \qquad \forall e = (x, y) \in E$  $d_s = 0$ 

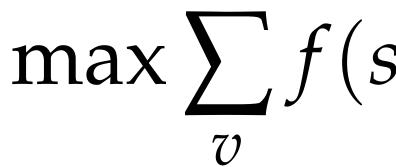
maxdt



## max flow as lp

## (G,c,s,t) G = (V,E) $c: E \to \mathbb{Z}_+$

## **INPUT:**



- $f(u,v) \ge 0$

max flow as lp

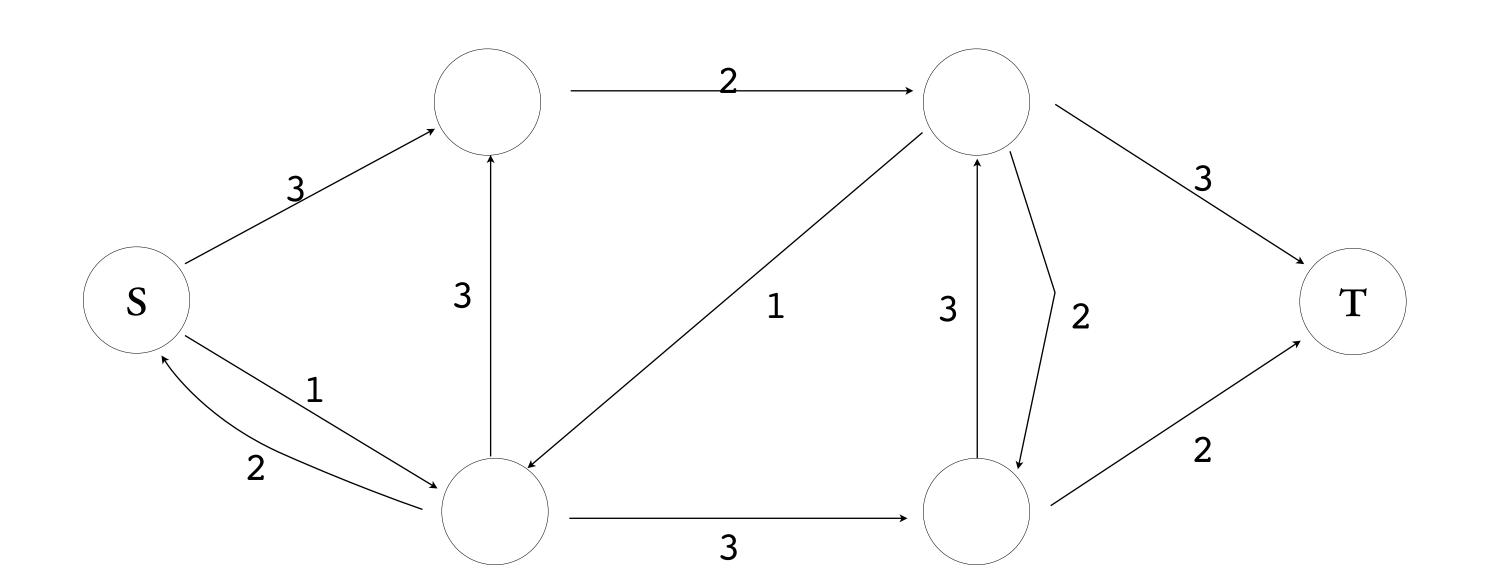
 $\max_{v} \sum_{v} f(s,v) - \sum_{v} f(v,s)$ 

 $f(u,v) \leq c(u,v)$ For (u,v) in E

 $\sum_{u} f(u, v) = \sum_{w} f(v, w) \quad \forall v$ 

FOR (U,V) IN E

$$\max \sum_{v} f(s, v) - \sum_{v} f(u, v) \le c(u, v)$$
$$\sum_{u} f(u, v) = \sum_{w} f(v, w)$$
$$f(u, v) \ge 0$$



max flow as lp

 $\int f(v,s)$ 

## for (u,v) in E

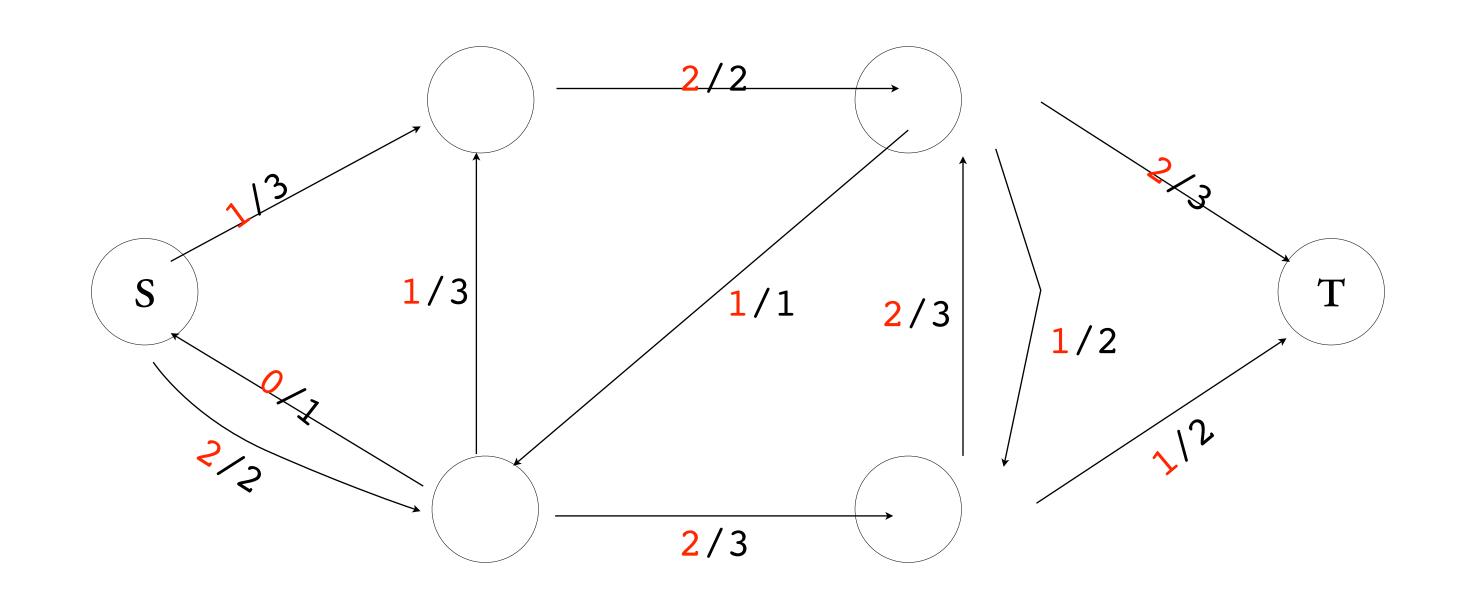
 $\forall v$ 

## for (u,v) in E

# min-cost flow as lp

INPUT:

(G,c,s,t) G = (V,E)  $c: E \to \mathbb{Z}_+$   $x: E \to \mathbb{Z}_+$  d



# min-cost flow as lp

# min-cost flow as lp

P  $f(e) \le c(e)$  $f(e) \geq 0$ 

 $\min x_e \cdot f(e)$ 

 $\sum_{u} f(u, v) = \sum_{w} f(v, w)$  $\sum f(s, v) - \sum f(v, s) = d$