CPS 196.2

Expressive negotiation over donations

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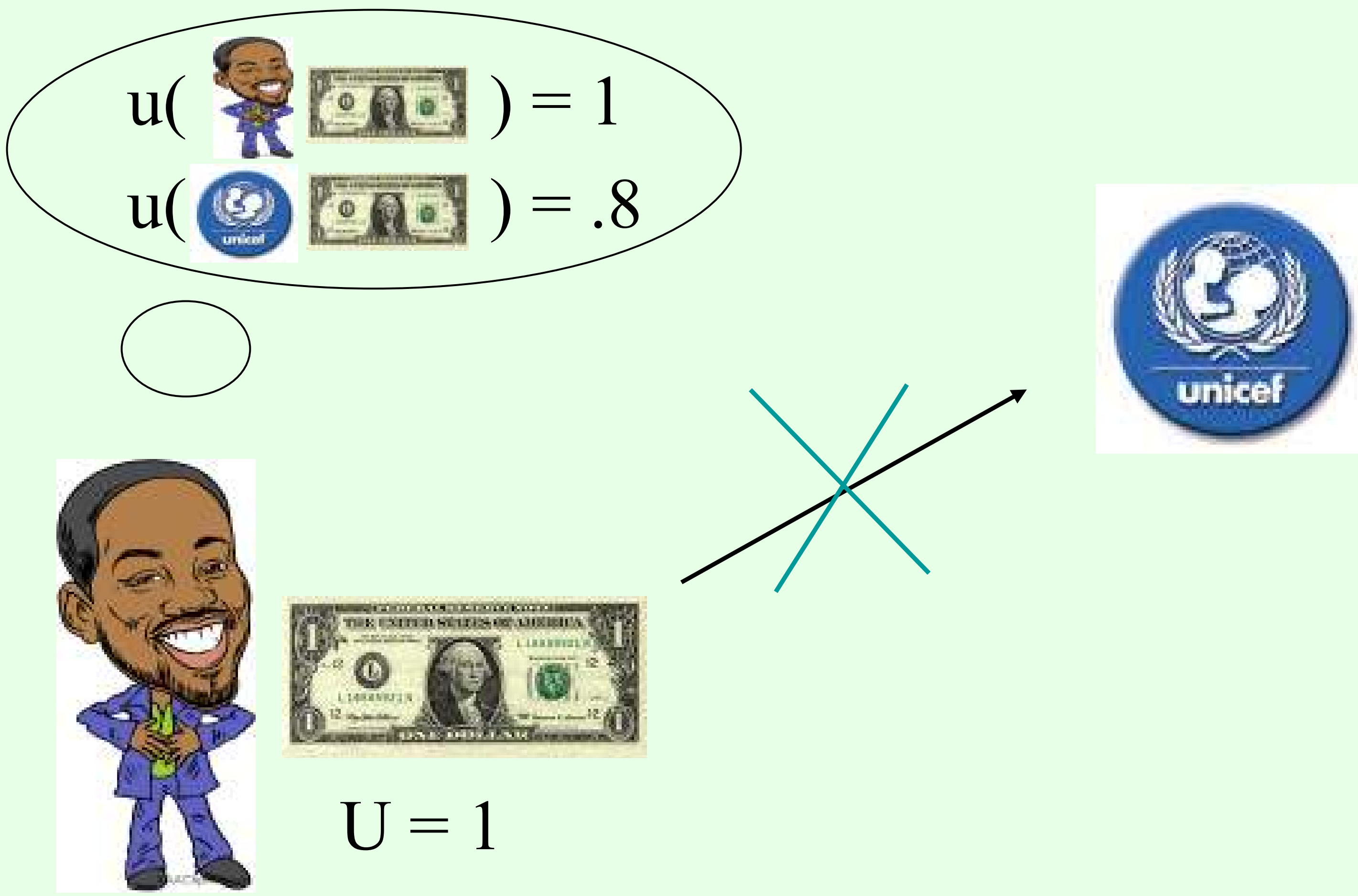
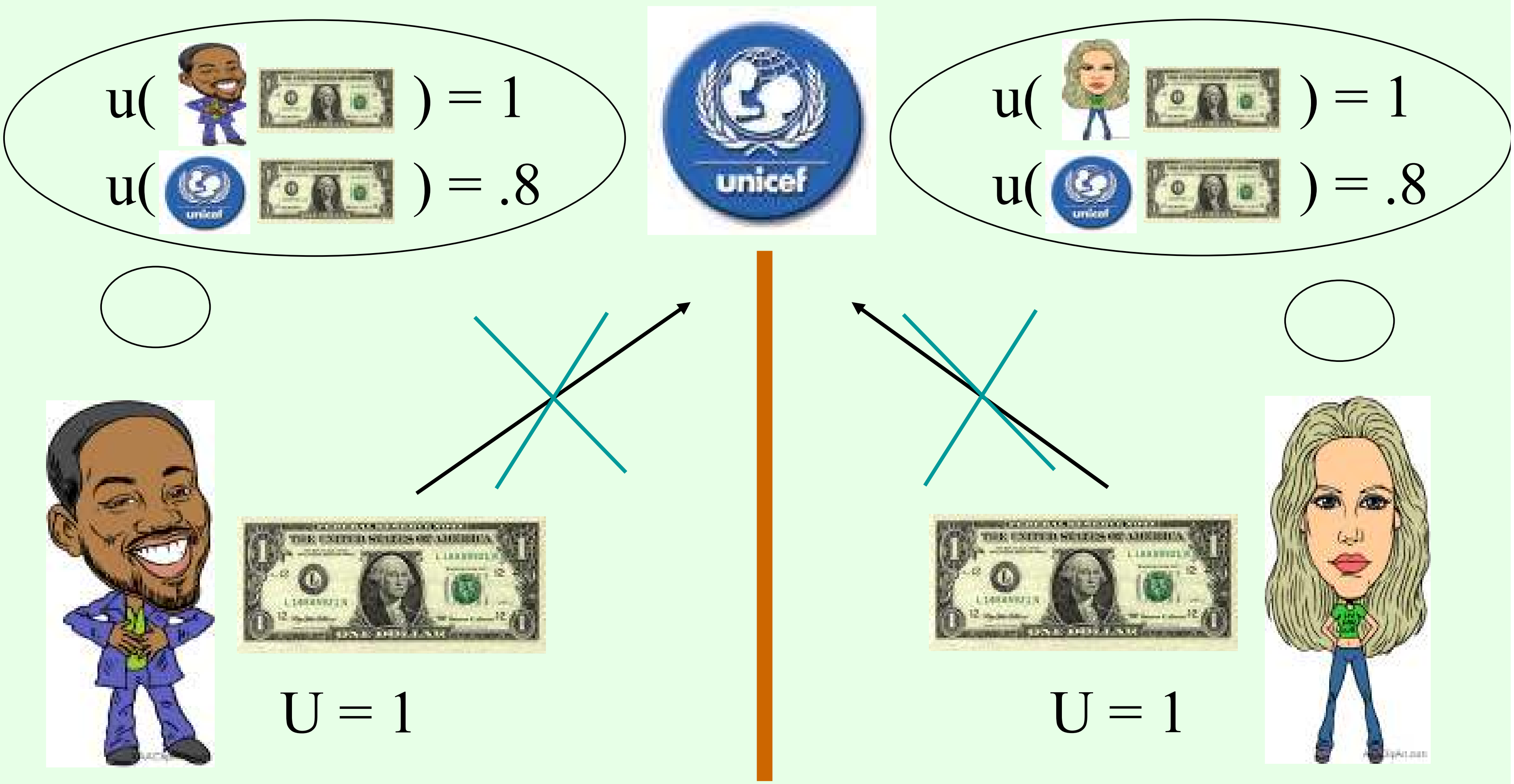
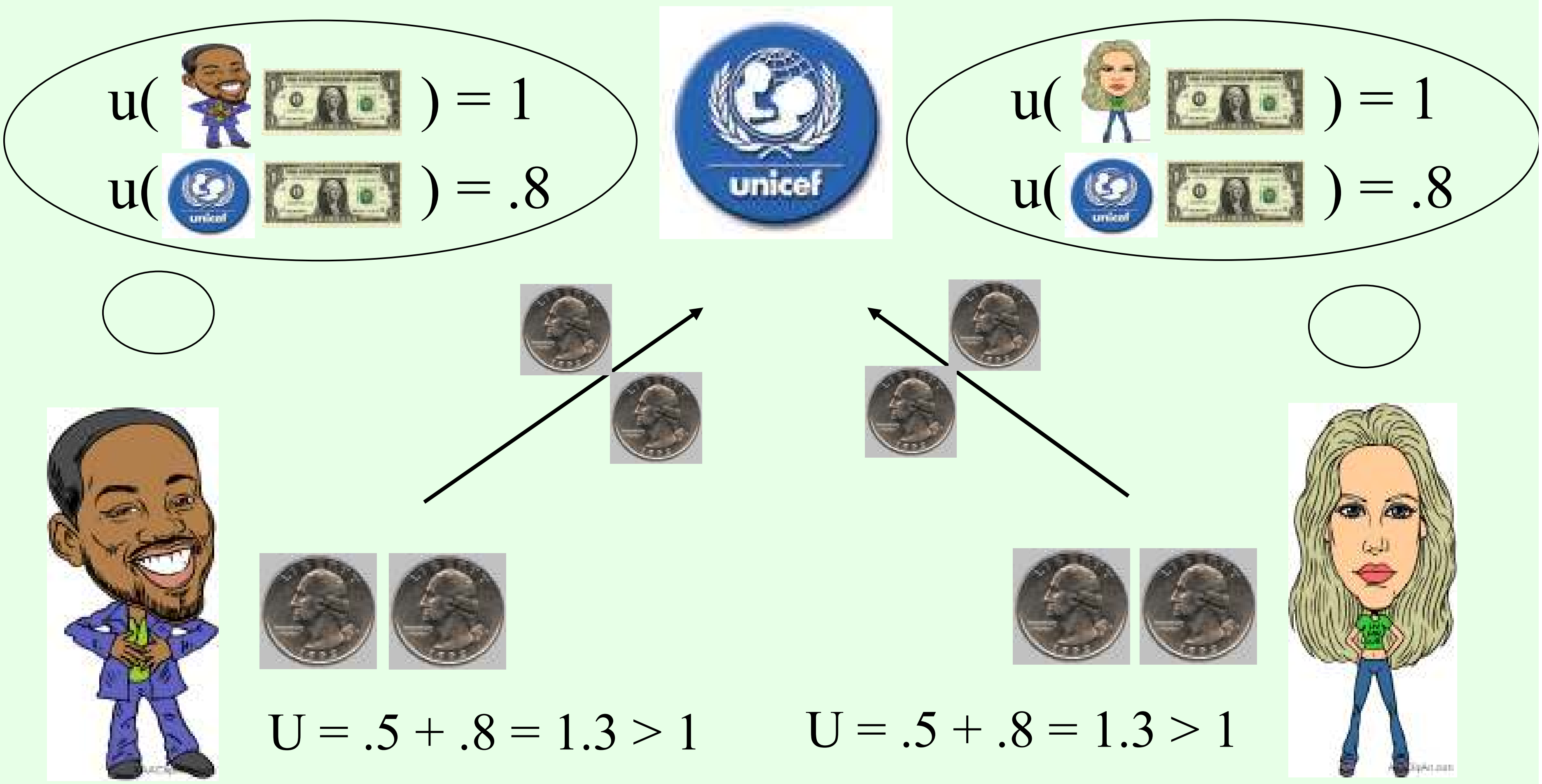
One donor (bidder)



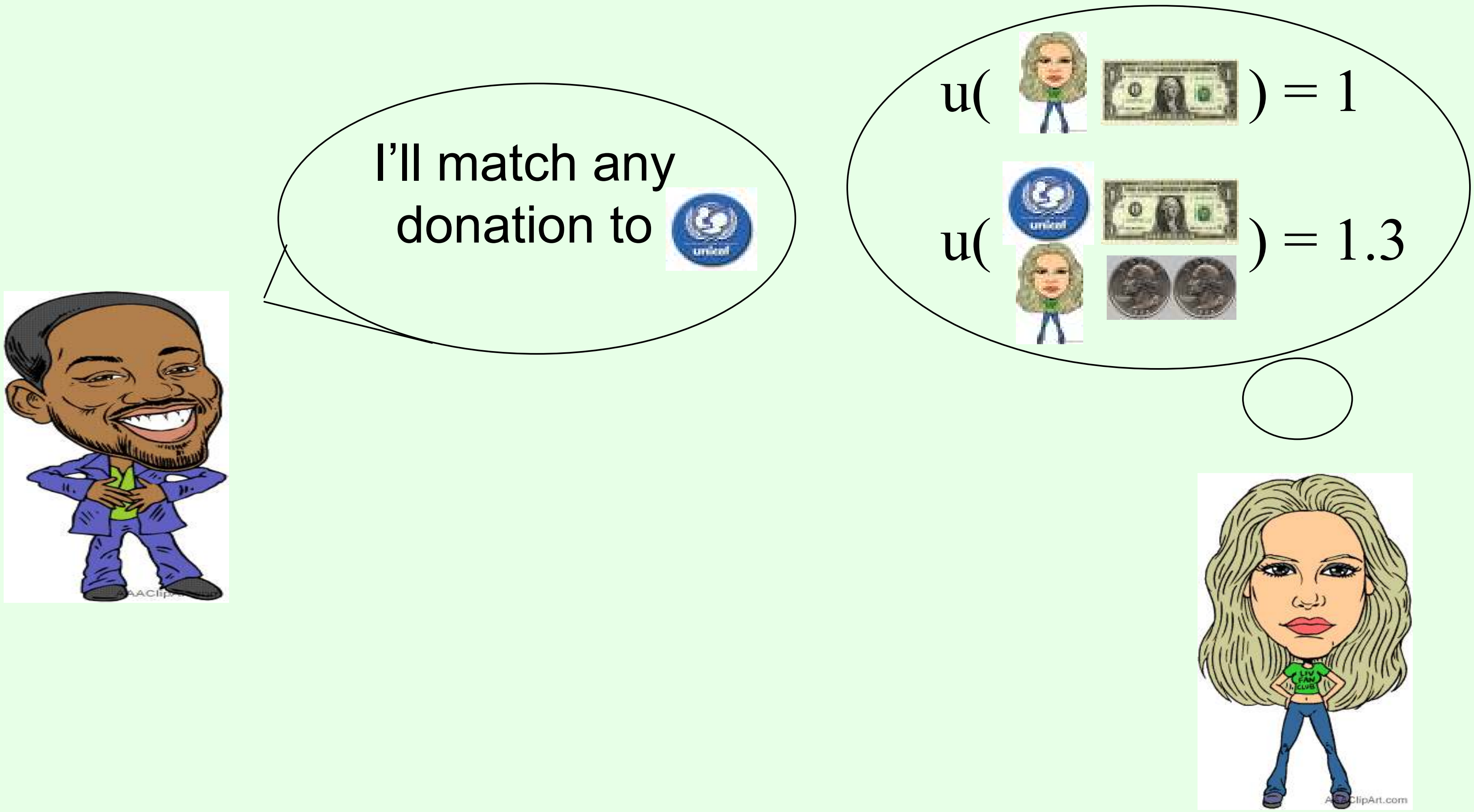
Two independent donors



Two donors with a contract

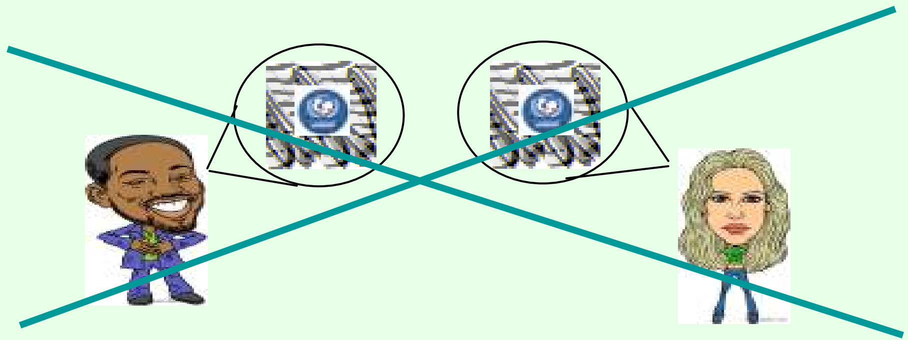


Contracting using matching offers

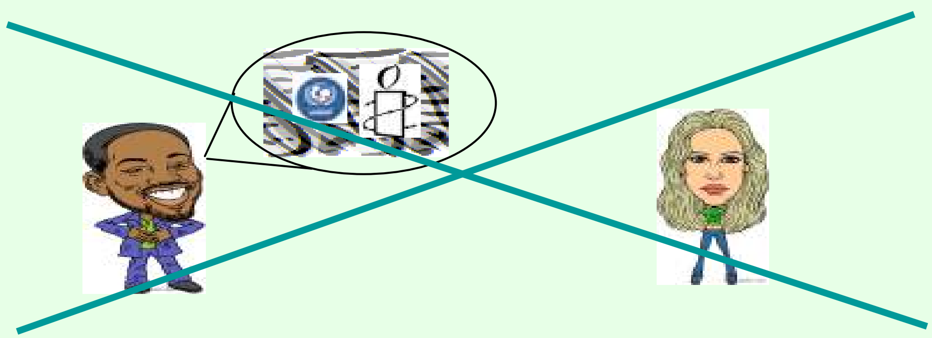


Limitations of matching offers

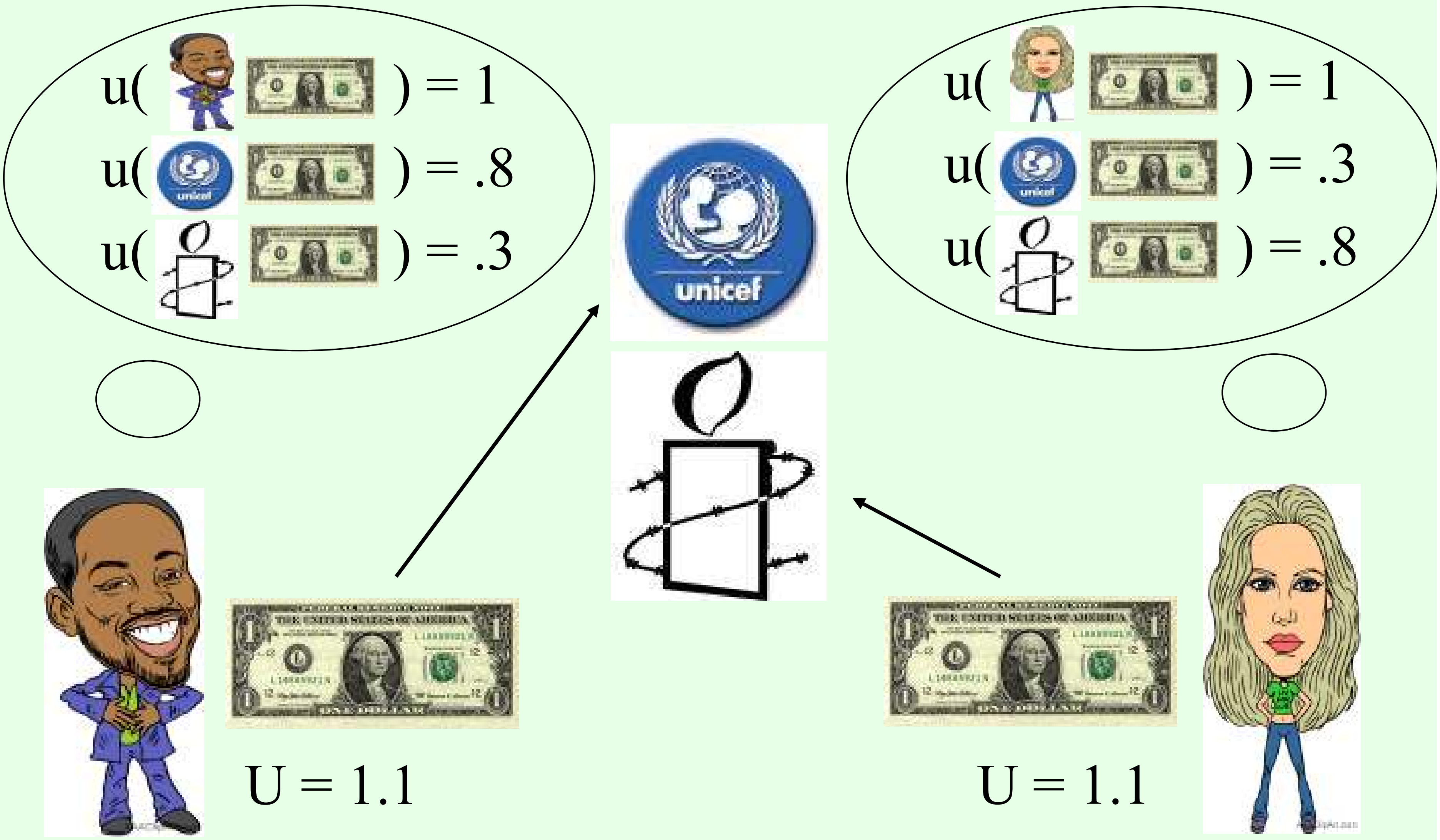
- One-sided



- Involve only a single charity



Two charities



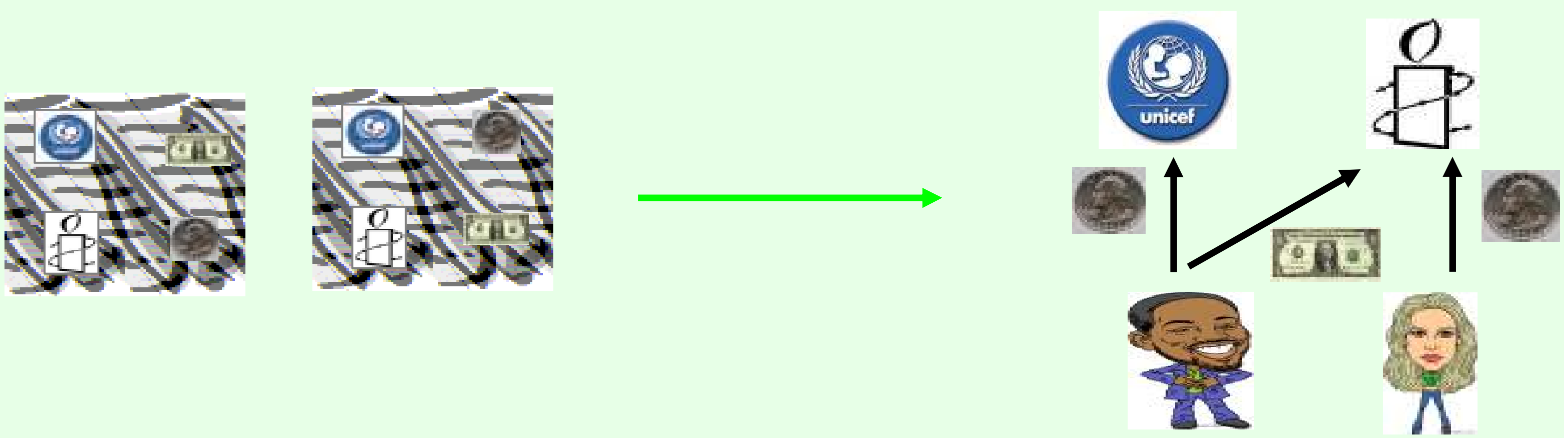
A different approach

- Donors can submit bids indicating their preferences over charities
- A center accepts all the bids and decides who pays what to whom

What do we need?

- A general bidding language for specifying "complex matching offers" (*bids*)

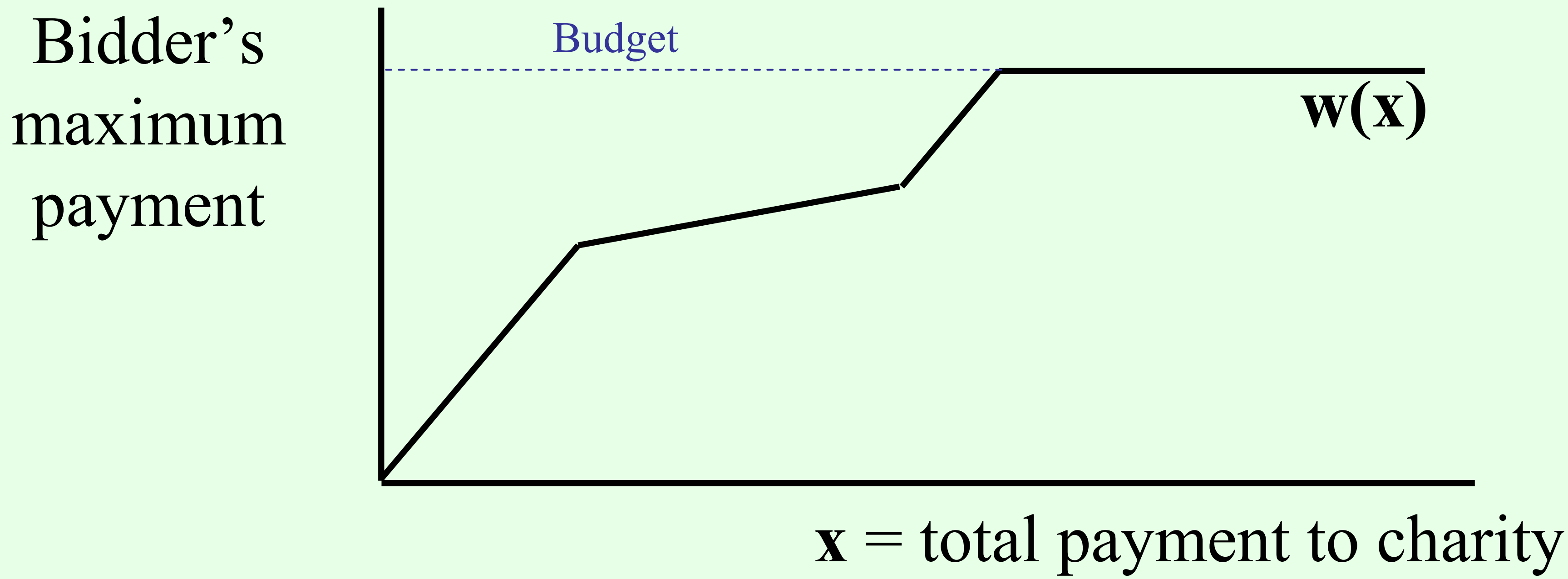
- Algorithms for the clearing problem (given the bids, who pays what to whom)



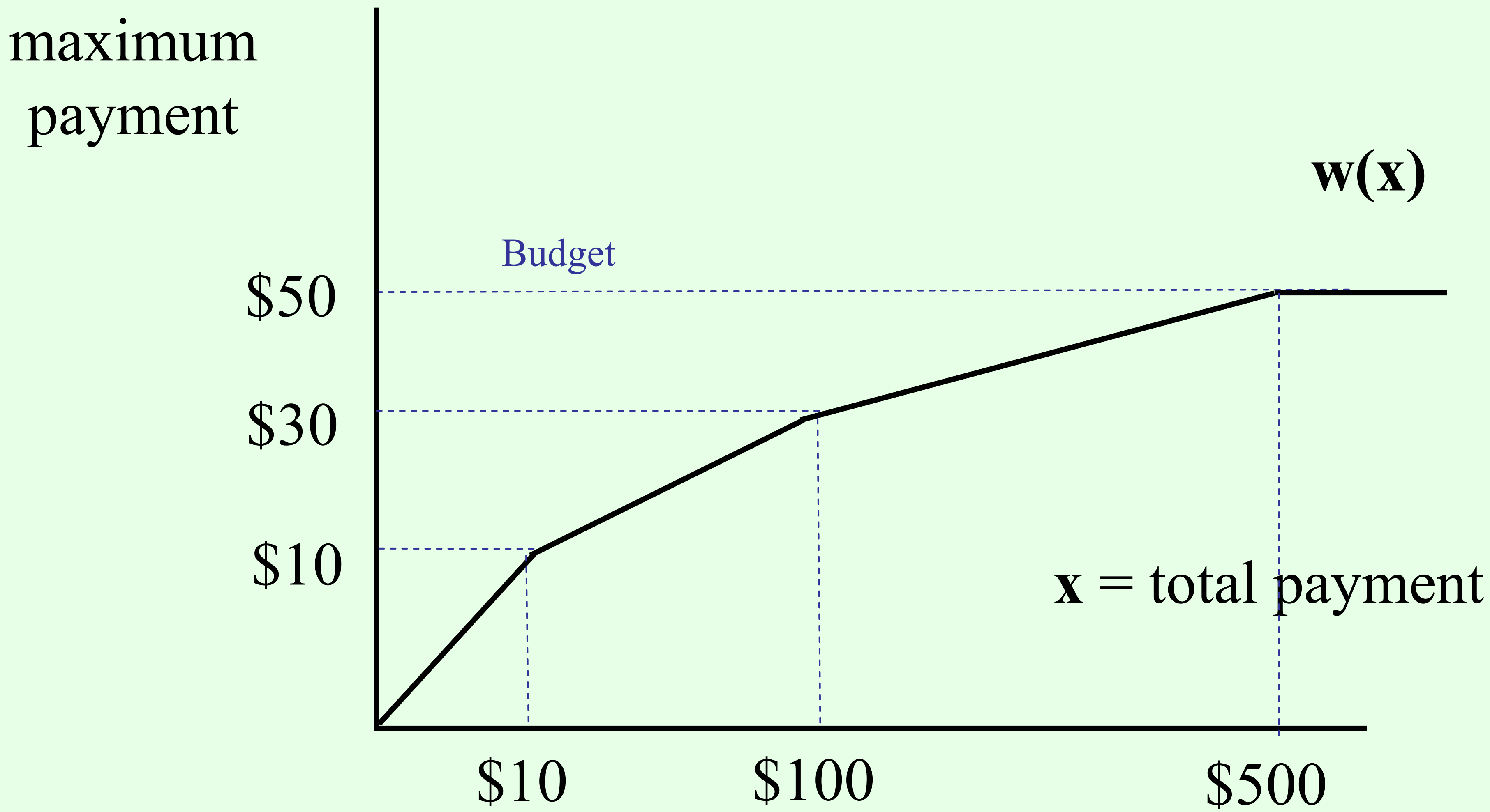
One charity

- A bid for one charity:

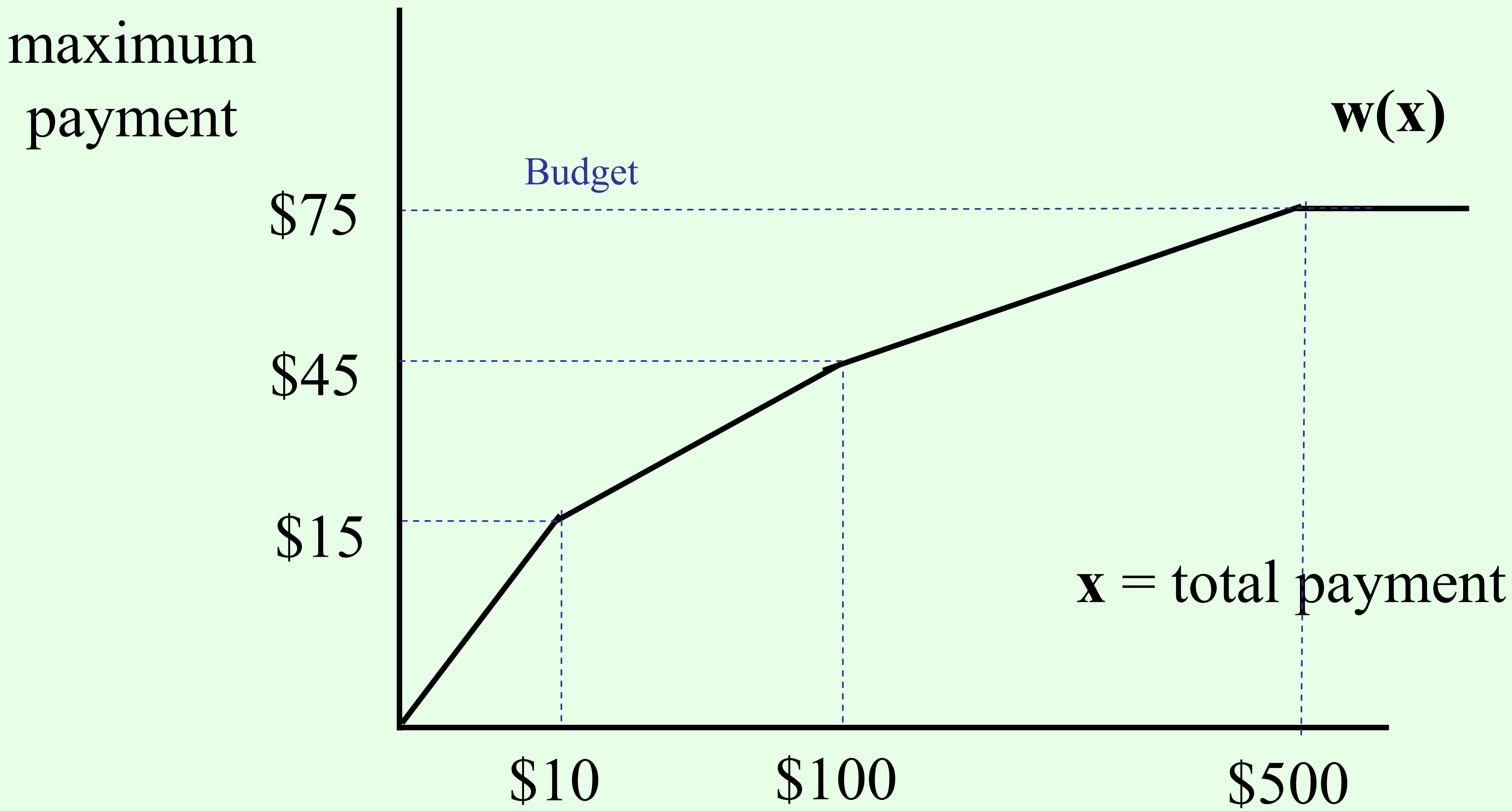
*"Given that the charity ends up receiving a total of **x** (including my contribution), I am willing to contribute at most **w(x)**"*



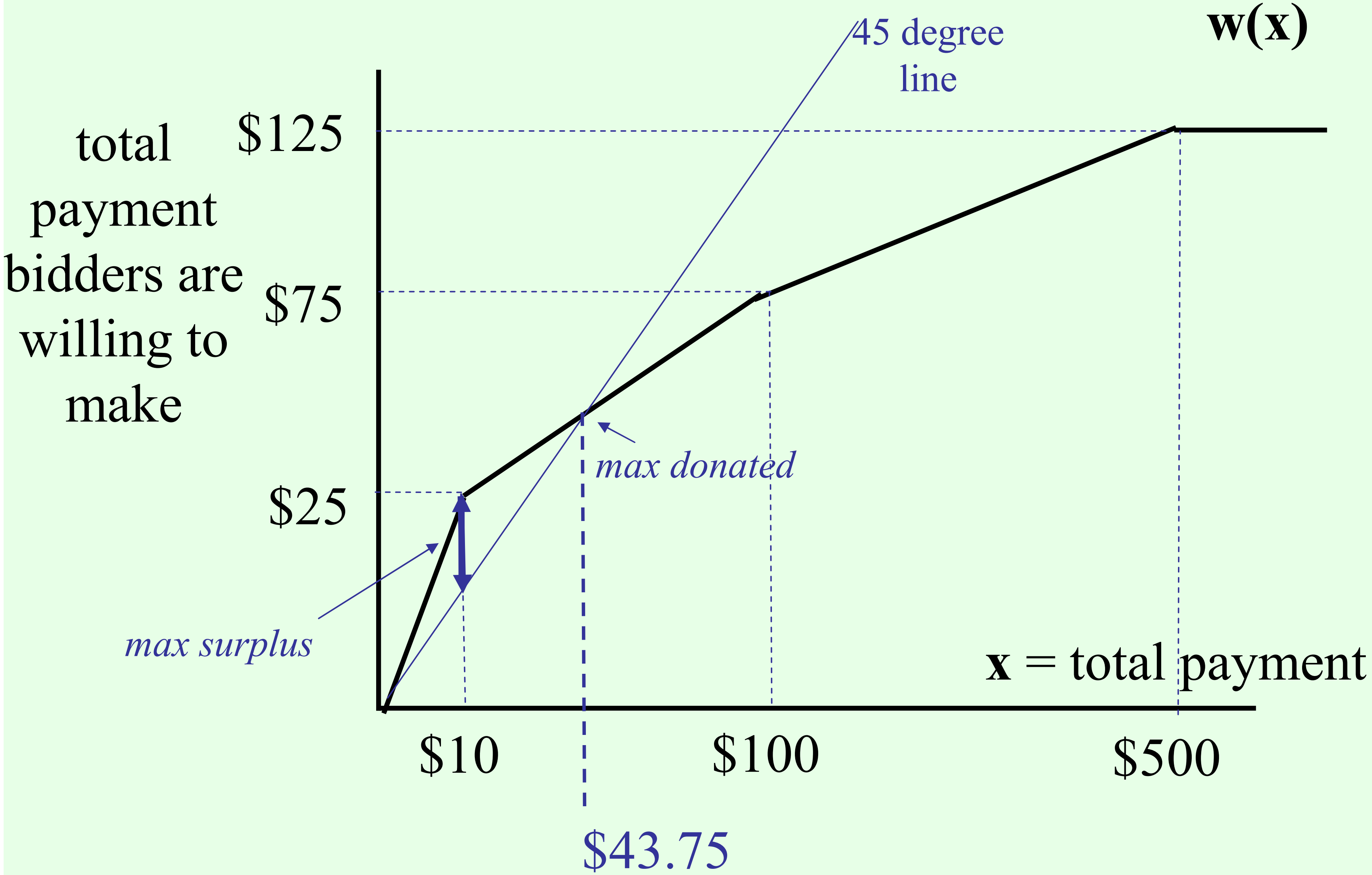
Bid 1



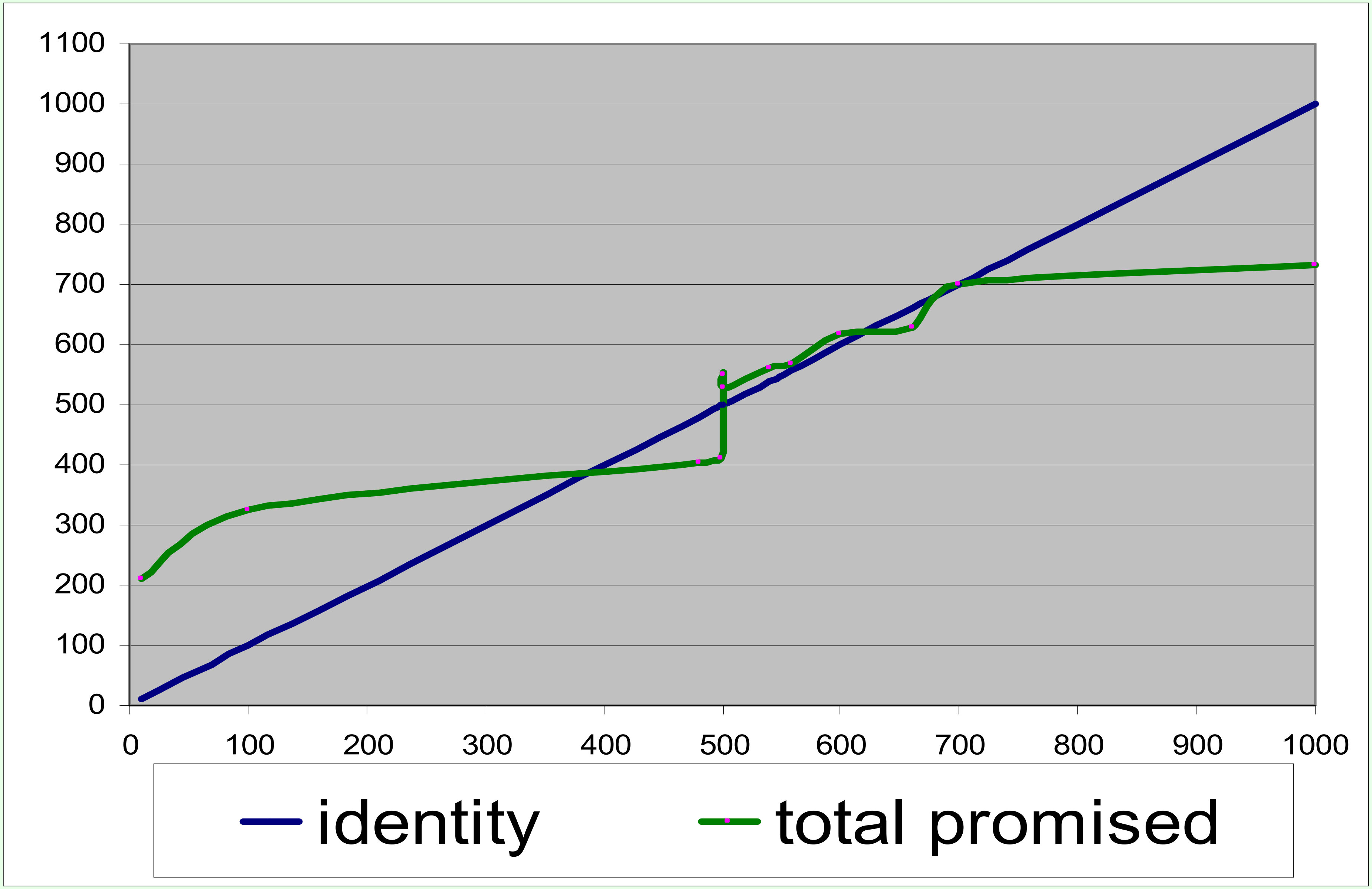
Bid 2



Current solution

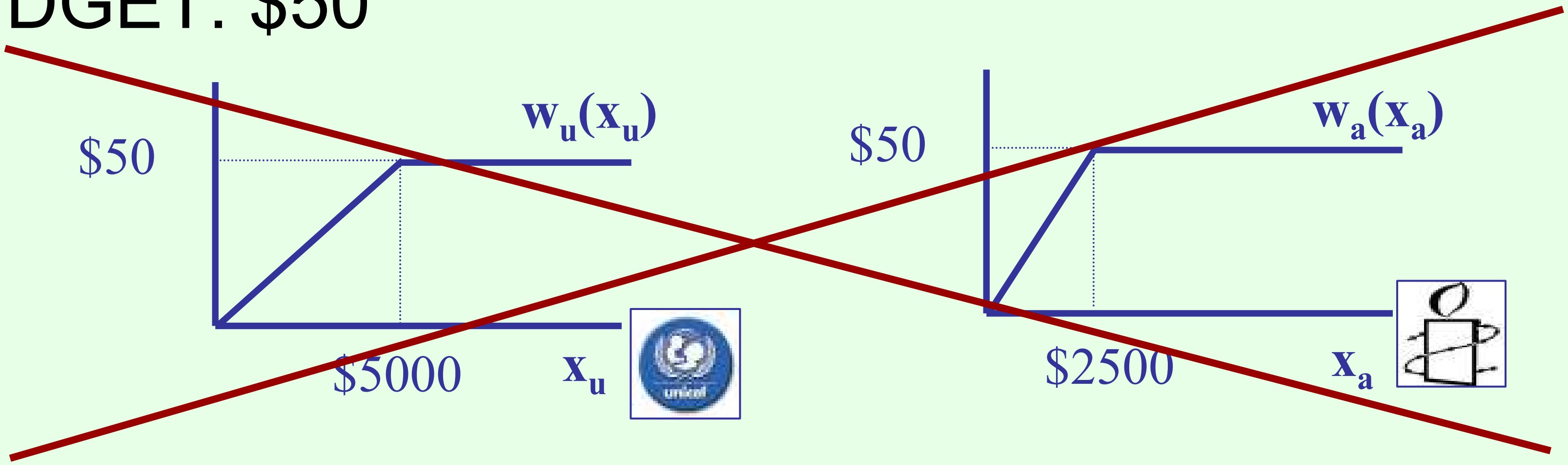


Tsunami event (Dagstuhl 05)



Problem with more than one charity

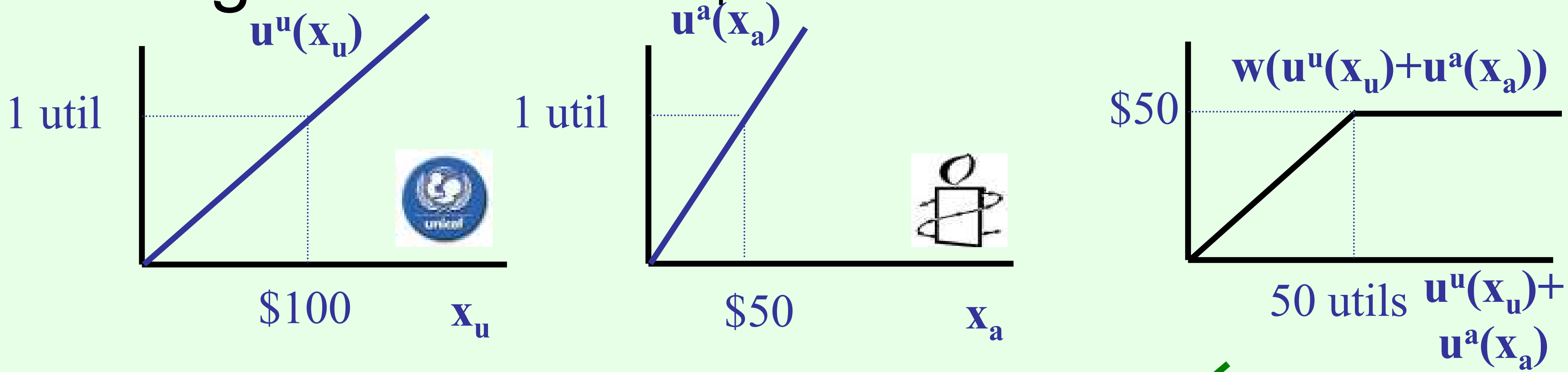
- Willing to give \$1 for every \$100 to UNICEF
- Willing to give \$2 for every \$100 to Amnesty Int'l
- BUDGET: \$50



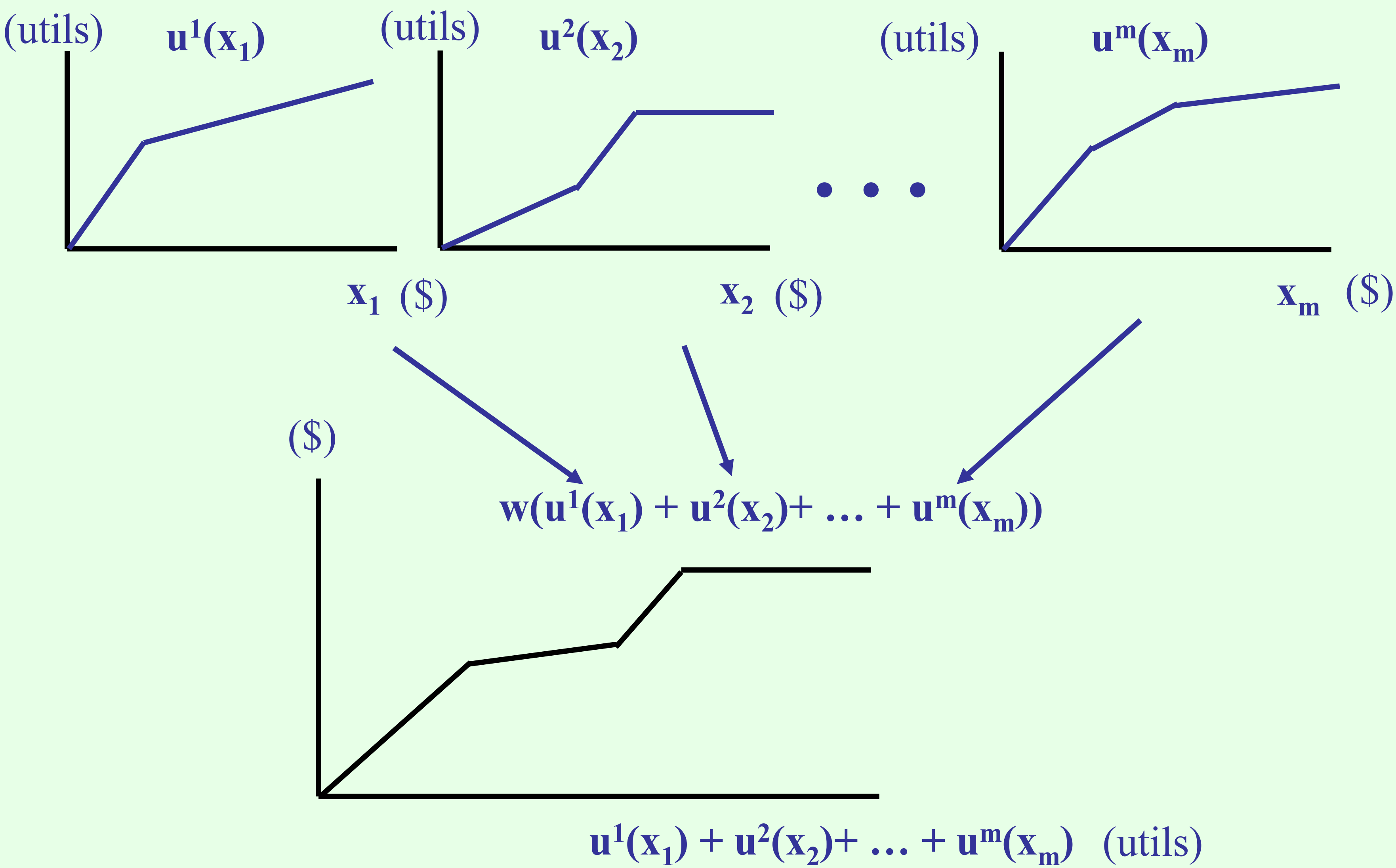
- Could get stuck paying \$100!
- Most general solution: $\mathbf{w}(x_1, x_2, \ldots, x_m)$
  - Requires specifying exponentially many values

Solution: separate *utility* and *payment*; assume utility decomposes

- Willing to give $1 for every $100 to UNICEF
- Willing to give $2 for every $100 to Amnesty Int'l
- Budget constraint: $50

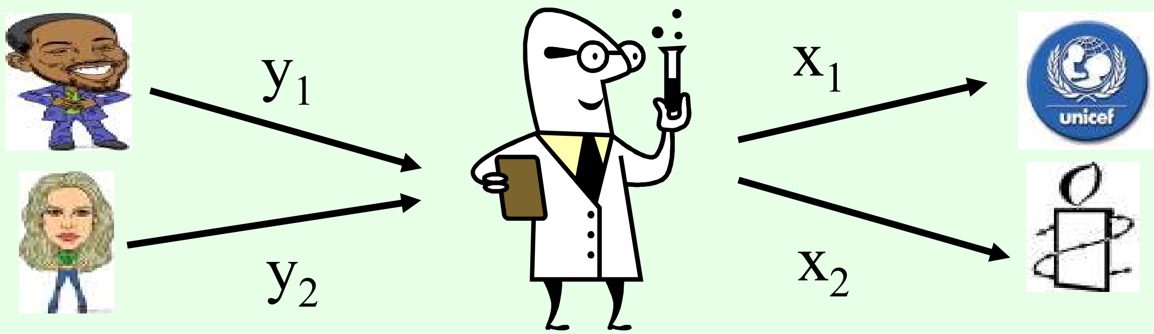


The general form of a bid



What to do with the bids?

- Decide $x_1, x_2, \ldots, x_m$ (total payment to each charity)
- Decide $y_1, y_2, \ldots, y_n$ (total payment by each bidder)

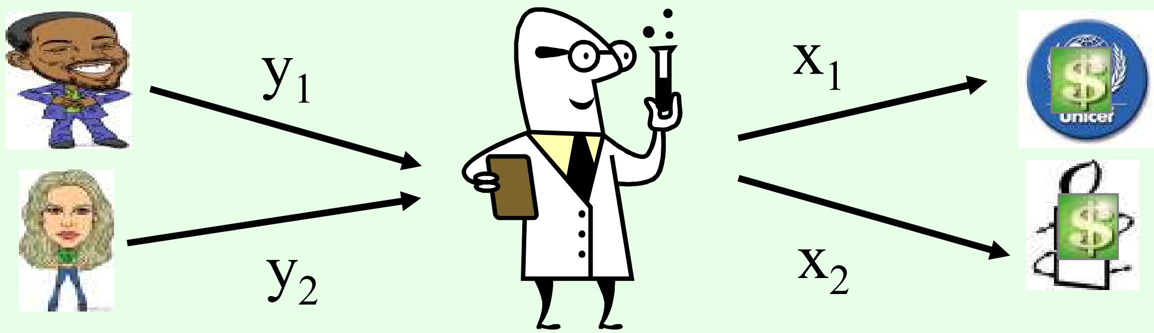


- Say $x_1, x_2, \ldots, x_m$; $y_1, y_2, \ldots, y_n$ is *valid* if
  - $x_1 + x_2 + \ldots + x_m \leq y_1 + y_2 + \ldots + y_n$ (no more money given away than collected)
  - For any bidder j, $y_j \leq w_j(u_j^1(x_1) + u_j^2(x_2) + \ldots + u_j^m(x_m))$ (nobody pays more than they wanted to)

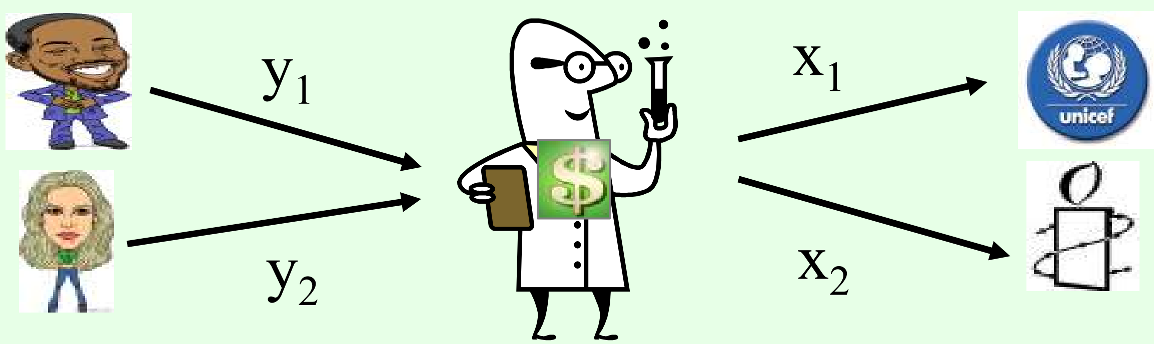
Objective

- Among valid outcomes, find one that maximizes

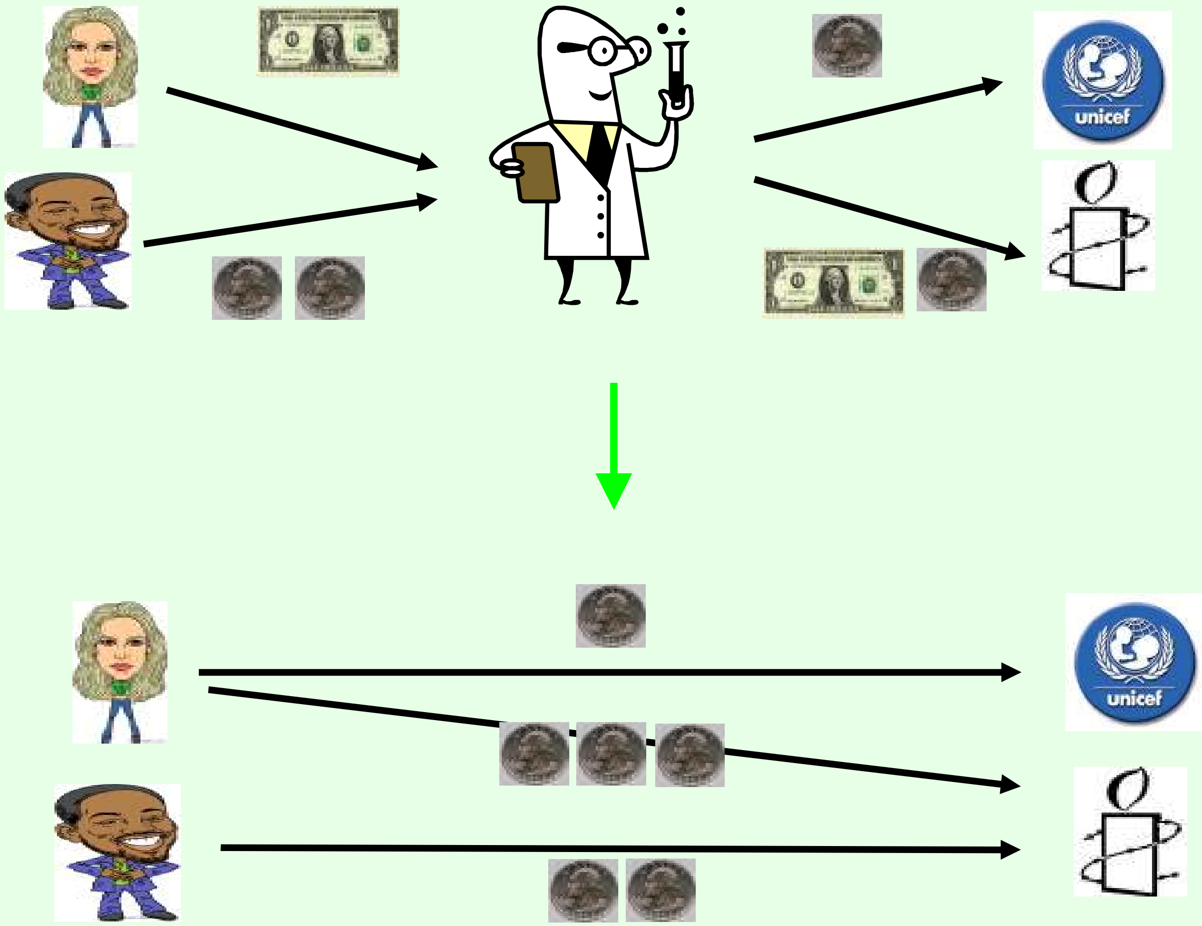
- *Total donated* = $x_1 + x_2 + \ldots + x_m$



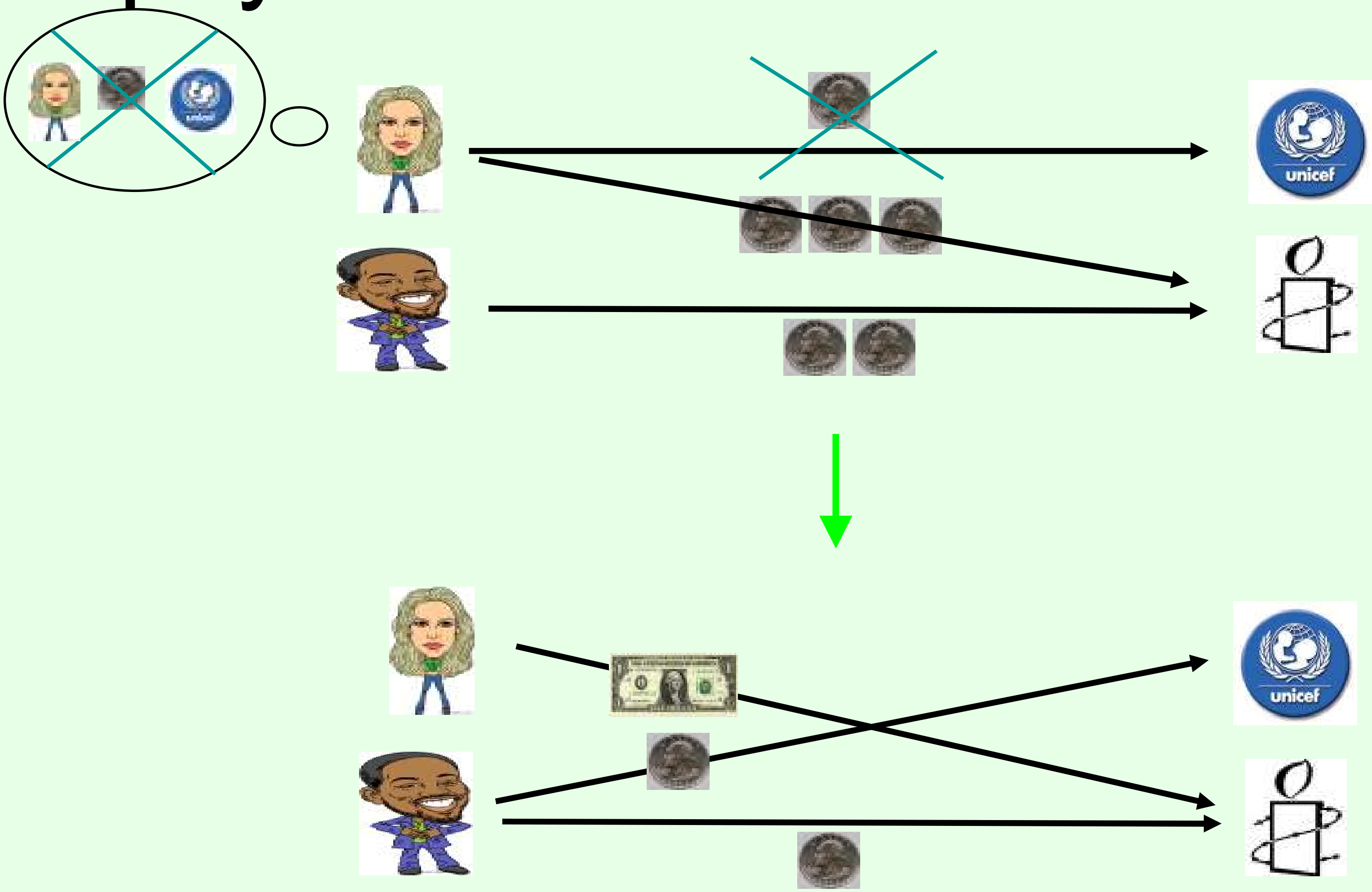
- *Surplus* = $y_1 + y_2 + \ldots + y_n - x_1 - x_2 - \ldots - x_m$



Avoiding indirect payments



No payments to disliked charities

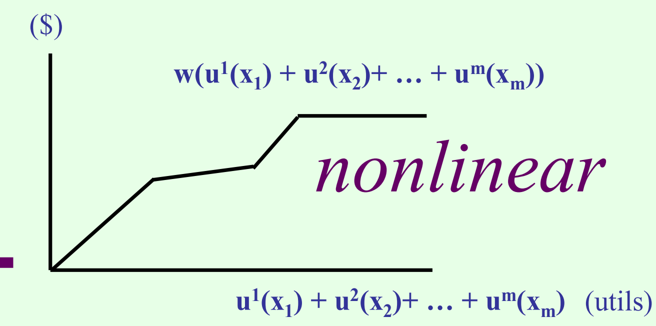


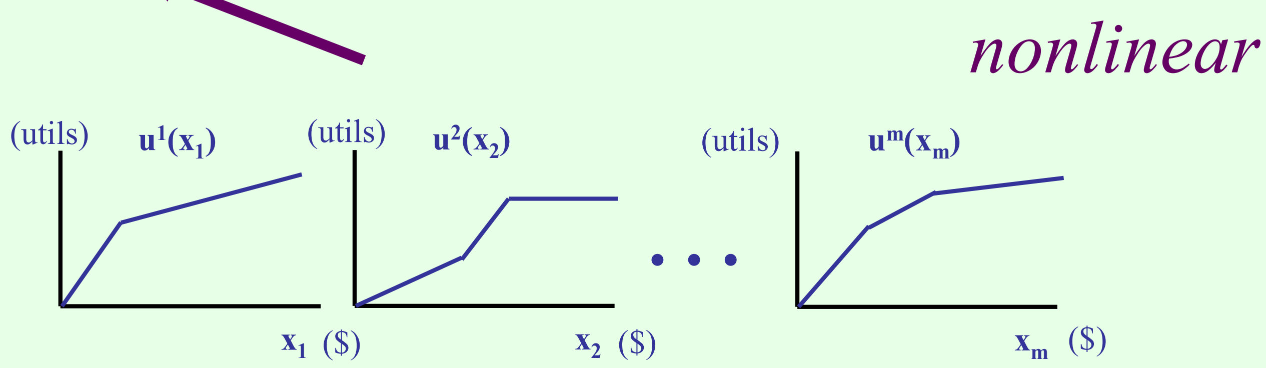
Hardness of clearing

- NP-complete to decide if there exists a solution with objective > 0
- That means: the problem is inapproximable to any ratio (unless P=NP)

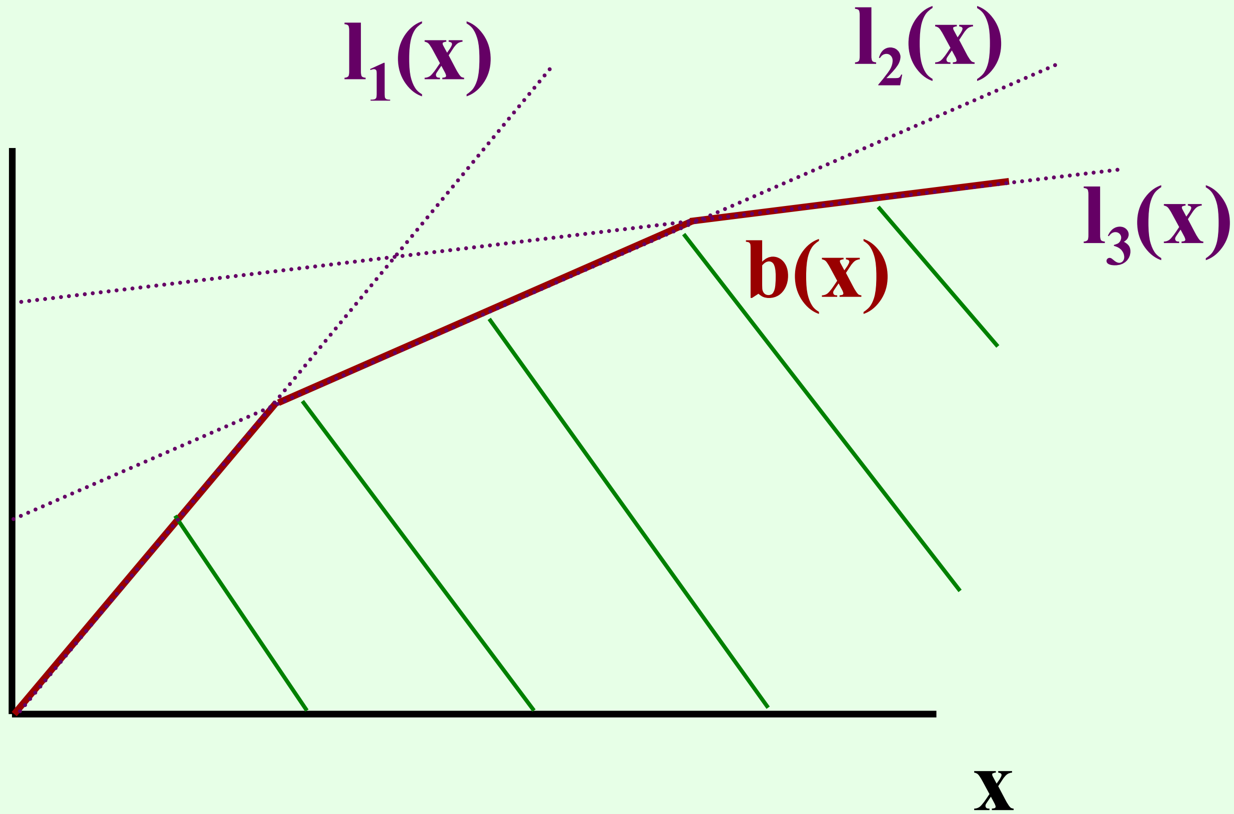
General program formulation

- *Maximize*
  - $x_1 + x_2 + \ldots + x_m$, OR
  - $y_1 + y_2 + \ldots + y_n - x_1 - x_2 - \ldots - x_m$
- *Subject to*
  - $y_1 + y_2 + \ldots + y_n - x_1 - x_2 - \ldots - x_m \geq 0$
  - For all j: $y_j \leq w_j(u_j^1 + u_j^2 + \ldots + u_j^m)$
  - For all i, j: $u_j^i \leq u_j^i(x_i)$





Concave piecewise linear constraints



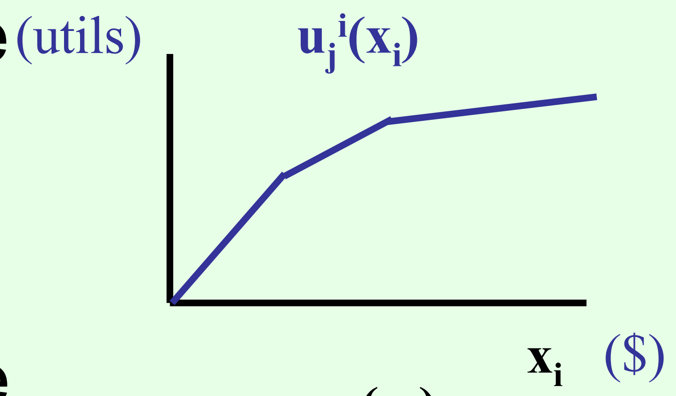
$y \le b(x)$ ⟶ $y \le l_1(x)$

$y \le l_2(x)$

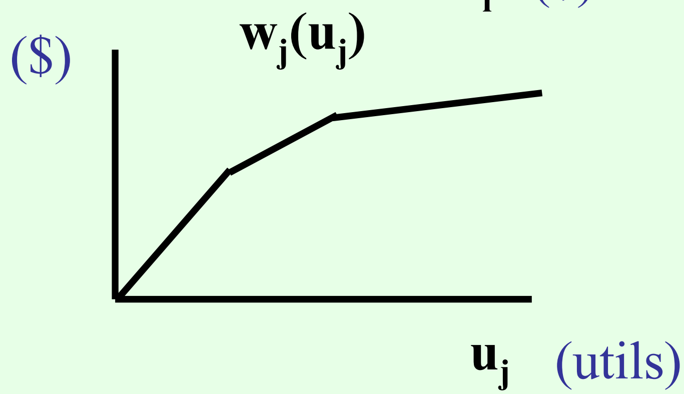
$y \le l_3(x)$

Linear programming

- So, if all the bids are *concave*…
  - All the u_j^i are concave



  - All the w_j are concave



- Then the program is a linear program (solvable to optimality in polynomial time)
- Even if they are not concave, can solve as MIP