MS&E 246: Game Theory with Engineering Applications

Lecture 1

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Outline

- Administrative stuff
- Course introduction
- A game

Administrative details

- My e-mail: ramesh.johari@stanford.edu
- Course assistant:

  Christina Aperjis, caperjis@stanford.edu
- Website:

  eeclass.stanford.edu/msande246

  All students must sign up there,
  and keep up with announcements

Administrative details

- 6-7 problem sets

  Assigned Thursday, due following Thursday in box outside Terman 319

  No late assignments accepted
- Midterm to be held February 8 (in class)

Big picture

Economics and engineering are tied together more than ever

Game theory provides a set of tools we can use to study problems at this interface

Motivating examples

- Electronic marketplaces
  - eBay auctions:
    Fixed termination time
  - Amazon auctions
    Terminate after 10 minutes of inactivity

Which yields higher revenue?

Motivating examples

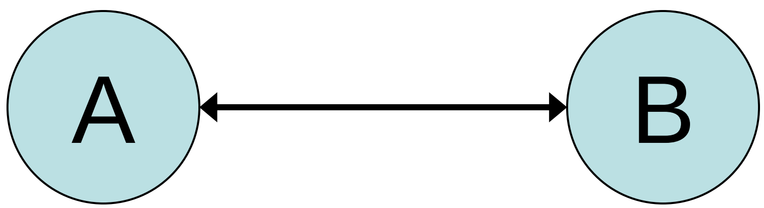
- Internet resource allocation
  - TCP: regulates flow of packets through the Internet
  - Malicious users can grab much more than “fair” share
  - How do we design “fair”, “efficient” allocation protocols that are robust to gaming?

Motivating examples

- Electricity markets
  - Electricity can't be stored, and must be reliable
  - Market failure is disastrous (e.g., California in 2000)
  - How do we design efficient, sustainable markets?

Internet provider competition

- Internet = 1000s of ASes (autonomous systems)
- Bilateral contracts between ASes:



- Transit vs. peer contracts

ISP contracts

- Transit vs. peer contracts
  - Transit:
    If A pays B, then
    A agrees to carry all traffic to/from B
  - Peer:
    A and B are of similar size,
    and agree to exchange traffic
    terminating in each other's network

Problems in the ISP industry

- In 2002, seven dominant players:
  - Sprint
  - AT&T
  - MCI/UUnet
  - Qwest
  - C&W
  - Level3
  - Genuity

Problems in the ISP industry

- In 2002, seven dominant players:
  - Sprint (subsidized by wireless)
  - AT&T ACQUIRED (SBC)
  - MCI/UUnet ACQUIRED (Verizon)
  - Qwest $18B debt
  - C&W R.I.P. (in U.S.)
  - Level3 (merged w/Genuity)
  - Genuity ACQUIRED (Level3)

Econ 101, pt. 1: war of attrition

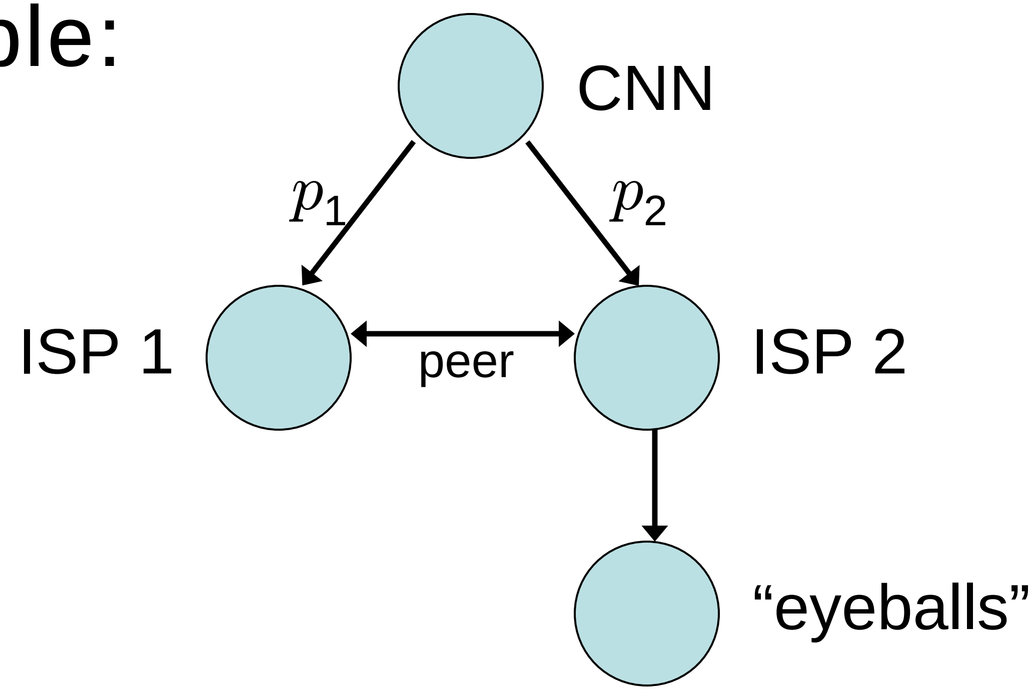
- Pricing below marginal cost

$\Rightarrow$ War of attrition (repeated game):

Lose money now in hopes of being last firm standing

Econ 101, pt. 2: Bertrand

- Example:



- If $p_1 < p_2$, then ISP 2's profit = zero

The future

- Econ 101 captures the essence:
  - cutthroat pricing
  - massive financial losses
  - “last firm standing” mentality

- Question:

  Is a regulated monopoly the only endgame?

Engineering

What is the problem in Bertrand example?

ISP 2 receives no credit for the value generated.

Current protocols don't expedite transmission of value information.

$\Rightarrow$ How do we build economically robust, informative protocols?

This course

We will develop the basics of noncooperative game theory...

...but with an eye towards connection with engineering applications.

Our first game

Two players each have a budget of \$4.00.

I have \$8.00.

Each player i puts \$$w_i$ in an envelope.

I give player i a fraction $w_i/(w_1 + w_2)$ of the \$8.00 that I have.

Whatever they did not put in the envelope, they keep for themselves.

Reasoning about the game

- What is the "best" a player can do?
- What is the best they can do together?
- Should they ever bid zero?
- Is there any bid a player should *never* make?
- What is the minimum a player can guarantee himself or herself?
- *What will happen when the game is played*?

Reasoning about the game

Player 1's payoff = 8 x $w_1 / (w_1 + w_2) + 4 - w_1$

Player 2's bid

Player 1's bid	**$0**	**$1**	**$2**	**$3**	**$4**
$0	$4.00	$4.00	$4.00	$4.00	$4.00
$1	$11.00	$7.00	$5.67	$5.00	$4.60
$2	$10.00	$7.33	$6.00	$5.20	$4.67
$3	$9.00	$7.00	$5.80	$5.00	$4.43
$4	$8.00	$6.40	$5.33	$4.57	$4.00

Reasoning about the game

Note that bidding $2 is always better than bidding $0, $3, or $4:

Player 2's bid

Player 1's bid

	$0	$1	$2	$3	$4
$0	$4.00	$4.00	$4.00	$4.00	$4.00
$1	$11.00	$7.00	$5.67	$5.00	$4.60
$2	$10.00	$7.33	$6.00	$5.20	$4.67
$3	$9.00	$7.00	$5.80	$5.00	$4.43
$4	$8.00	$6.40	$5.33	$4.57	$4.00

Reasoning about the game

If we anticipate player 2 will not bid $0, $3, or $4...

Player 2's bid

Player 1's bid

	$0	***$1***	***$2***	***$3***	***$4***
$0	$4.00	$4.00	$4.00	$4.00	$4.00
$1	$11.00	$7.00	$5.67	$5.00	$4.60
$2	$10.00	$7.33	$6.00	$5.20	$4.67
$3	$9.00	$7.00	$5.80	$5.00	$4.43
$4	$8.00	$6.40	$5.33	$4.57	$4.00

Reasoning about the game

...then we should always bid $2...

Player 2's bid

Player 1's bid

	$0	***$1***	***$2***	***$3***	***$4***
$0	$4.00	$4.00	$4.00	$4.00	$4.00
$1	$11.00	$7.00	$5.67	$5.00	$4.00
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$4	$8.00	$6.40	$5.33	$4.57	$4.00

Reasoning about the game

...and so should player 2.

Player 1's bid \ Player 2's bid	$0	$1	$2	$3	$4
$0	$4.00	$4.00	$4.00	$4.00	$4.00
$1	$11.00	$7.00	$5.67	$5.00	$4.60
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Reasoning about the game

- Does this way of reasoning about the game make sense?

- *Thought experiments:*

  What if the budgets are different?

  What if the size of the common pool is different?