The Prisoner's Dilemma

File transfer game:

- Alice has a file desired by Bob and vice versa
- simultaneously decide whether to upload or not
- benefit of download = 3
- cost of upload = 1

Equivalent: Prisoner's Dilemma.

Payoff matrix:

Bob's choice

Alice's choice

	upload	no upload
upload	2,2	-1,3
no upload	3,-1	0,0

outcome from collective optimization

outcome from individual optimization

special case of "Nash equilibrium"

Question: better to upload, or not?

- for the individual: dominant strategy to not upload => zero payoffs.
- for the collective: better to upload ((2,2) "Pareto dominates" (0,0))

Repeated Prisoner's Dilemma

Model #1: Alice, Bob play Prisoner's Dilemma n times (payoffs add).

- action in a stage i can depend on outcomes of stages 1, 2, ..., i-1.

Note: at stage n, dominant strategy to defect.

=> continuing backward, only justifiable behavior in model is to always defect.

"backward induction"

Model #2: After each stage, game ends with some probability p.

Claim: if p is small enough, cooperation is justified.

	C	D
C	2,2	-1,3
D	3,-1	0,0

The Tit-for-Tat Strategy

Setting: repeated Prisoner's Dilemma, each stage the last with probability p.

Tit-for-Tat: ① in stage 1, cooperate
② in stage $i \geq 2$, do whatever other player did in stage $i-1$.

Claim: if $p \leq \frac{1}{2}$ and Alice plays tit-for-tat, Bob should cooperate.

Reason: Consider stage 1.

$\Rightarrow$ if $p < \frac{1}{2}$, short-term gain of defection outweighed by long-term cost!

	stage-1 payoff	stage 2
cooperate	2	$\geq (1-p)2$
defect	3	≤ 0

≤ 3

$\geq 2(2-p)$ > 3 if $p < \frac{1}{2}$

Tit-for-Tat in BitTorrent

BitTorrent: dominant paradigm in P2P file distribution.

Strategy: - break big file into many pieces (e.g., 10MB each)

- users exchange file pieces

⇒ transforms single-shot Prisoner's Dilemma into repeated Prisoner's Dilemma!

Default client: (ignoring bootstrapping)

- broadcast which files you have
- request download from all peers with relevant file pieces
- split upload capacity equally across s peers - chosen using Tit-for-Tat! (reward others' uploads)

(e.g., s=4)