Communication Amid Uncertainty

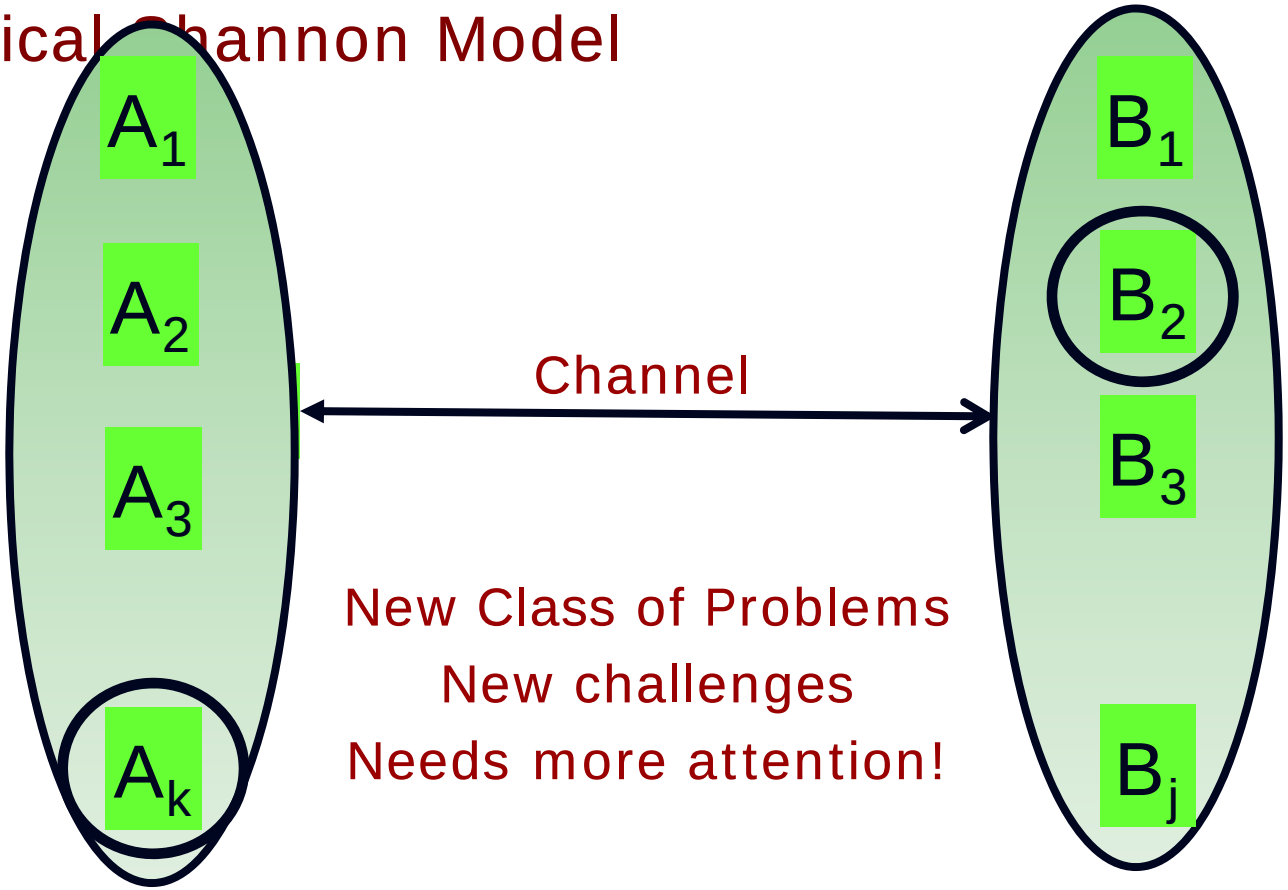
Madhu Sudan
Microsoft Research

Uncertainty in Communication?

- Always an issue … but usually uncertainty in channel of communication.
- Lately, however … Also have to worry about uncertainty of communicating "agents" about each other.
  - E.g.: How would you like to archive your family photographs "digitally" when you are uncertain which format will be viewable? Would you compress?
- New class of questions … new solutions needed.
  - First, a new model.

Modelling uncertainty

Uncertain Communication Model
Classical Shannon Model



New Class of Problems
New challenges
Needs more attention!

Example: Compression

- How would you compress information if Sender and Receiver don't have a common prior?
  - Message space $\mathbb{M} = \{1, \ldots, N\}$
  - Encoding: $E(P, m)$, P dist. on $\mathbb{M}$, $m \leftarrow_P \mathbb{M}$.
  - Decoding: $D(Q, y)$. (Q dist., $y \in \{0,1\}^*$)
  - Minimize $\mathrm{E}_{m \leftarrow_P \mathbb{M}}[|E(P, m)|]$
  - Need: $D\big(Q, E(P, m)\big) = m$ provided $P \approx Q$
- Explored in
  - [Juba,Kalai,Khanna,S'11]: W. randomness.
  - [Haramaty,S'13]: Deterministic.
  - Models "natural" communication?

Misunderstanding and Meaning

- Bits lead to action
  - How can sender ensure receiver understands instruction and acts accordingly?
    - Incentive?
      - Receiver may not want to follow sender's instructions.
      - Or receiver may not understand ...
- Goal-oriented comm. [GoldreichJubaS.12]
  - Sender must have goal + sense progress.
  - Achievement of goal is "functional" defn. of communicating meaningfully.
  - Sufficient conditions for comm. meaningfully.

Communication as Coordination Game [Leshno,S.'13]

- Two players playing series of coordination games
  - Coordination?
    - Two players simultaneously choose 0/1 actions.
    - "Win" if both agree:
      - Alice's payoff: not less if they agree
      - Bob's payoff: strictly higher if they agree.
    - How should Bob play?
      - Doesn't know what Alice will do. But can hope to learn.
      - Can he hope to eventually learn her behavior and (after finite # of miscoordinations) always coordinate?
- Theorem:
  - Not Deterministically (under mild "general" assumptions)
  - Yes, with randomness (under mild restrictions)

Thank You!