BITS Pilani

Social Media Analytics

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Social Media Analytics
Lecture No. 11

Recap

Link Prediction – Recap

1. Local Heuristics

- Use **local neighborhood information**
- Assume nodes with **common neighbors** are likely to connect

- Examples:

  - Common Neighbors
  - Jaccard Coefficient
  - Adamic–Adar

- **Fast and scalable**, but ignore global structure

Recap

2. Global Heuristics

- Use **entire network structure**
- Consider **all paths** between nodes

- Examples:
  - Katz Index
  - Hitting time
  - commute time

- **More accurate**, but **computationally expensive**

Recap

Probabilistic Methods

- Represents the network using a **hierarchical structure**
- The hierarchy is unfolded as a **dendrogram**
- **Leaves** of the dendrogram represent network nodes
- **Internal nodes** represent groups / communities

Link Probability Estimation

- Each internal node r in the dendrogram is assigned a **probability** p_r
- For any two nodes u and v:
  - Find their **lowest common ancestor (LCA)** in the dendrogram
  - The probability of a link between u and v is:

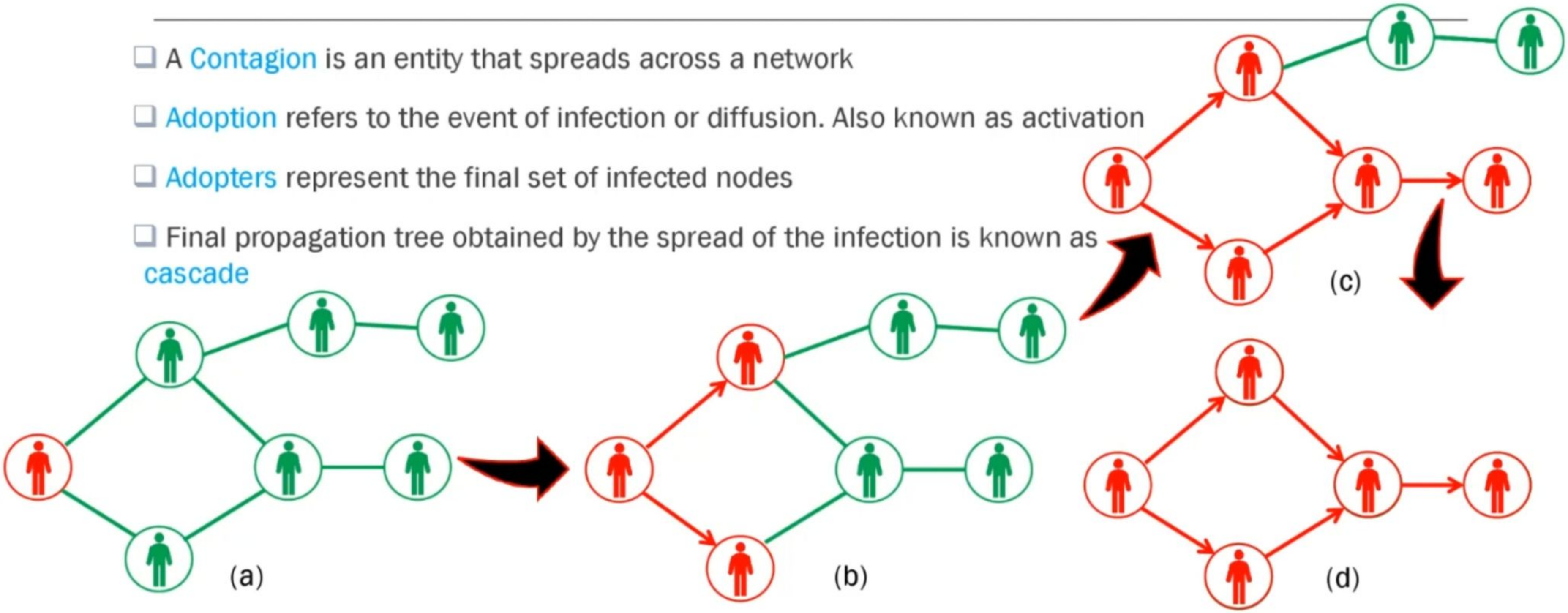
$$P(u, v) = p_{\mathrm{LCA}(u,v)}$$

Agenda

- Information discussion.
- Types of Diffusion MOdels
  - Decision-Based Diffusion Models
  - Probabilistic-Based Diffusion Models
- What are the advantage and disadvantage
- how they evolve over time

Information Diffusion: Terminologies

- A Contagion is an entity that spreads across a network
- Adoption refers to the event of infection or diffusion. Also known as activation
- Adopters represent the final set of infected nodes
- Final propagation tree obtained by the spread of the infection is known as cascade



How will you model diffusion models

Cascade Model: Decision-based Model

- Given a network, each node has the freedom to decide whether to adopt a contagion or not
- Originated from the idea of local interaction models described by Morris in 2000
- Decision at each node is influenced by the behavior of nodes in its neighborhood
- Nodes decide to adopt a new contagion driven by a direct benefit or payoff
- The payoff by adopting a contagion is directly proportional to the number of its neighbors that have adopted the same contagion
- Can be explained using a two-player coordination game
  - Given a number of strategies, the end goal of the players is to coordinate on the same strategy to maximize their payoffs

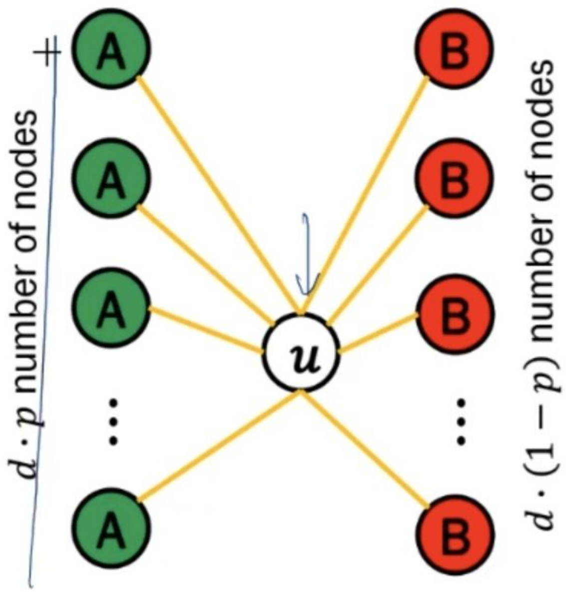
Decision-based Cascade Model: Two-player Coordination Game

u's decision	v's decision	Payoff
A	A	$a*$
B	B	$b*$
A	B	0
B	A	0

Payoff distribution for different adoption strategies
* a and b are positive constants

- A and B: two possible strategies that each node in network $G(V, E)$ could adopt
- Each node u will play its own independent game
- Final payoff is the sum of payoffs for all the games
- To calculate the required threshold at which a node u would decide to go with strategy A

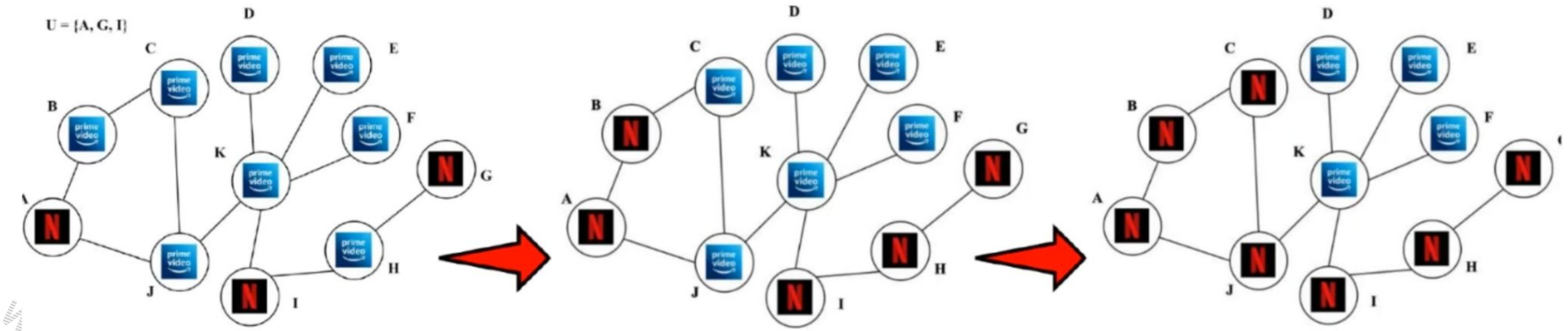
Decision-based Cascade Model: Two-player Coordination Game



- Node u has d neighbours
  - p fraction of neighbours adopt strategy A
  - Rest adopts strategy B
- Total payoff for node u if it goes with strategy A = $a \cdot d \cdot p$
- Total payoff for node u if it goes with strategy B = $b \cdot d \cdot (1-p)$
- Node u would adopt contagion A if

$$p \geq \frac{b}{a+b}$$

Decision-based Cascade Model: Illustration



The threshold for a switch from Amazon Prime Video to Netflix at a node is 0.50

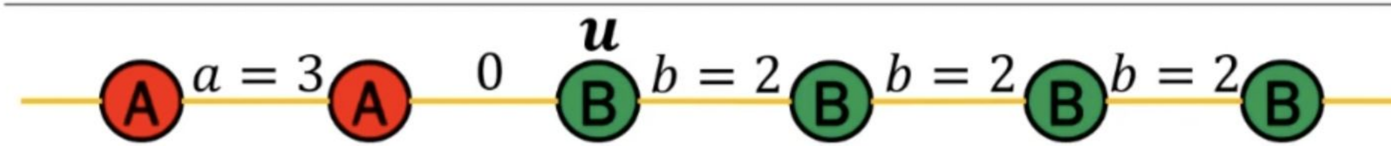
Multiple Choice Decision-based Cascade Model

- Allows a node to adopt more than one strategy/behavior
- In case a node prefers to go with both the strategies A and B, it would incur an additional cost c
- The revised payoff distribution:

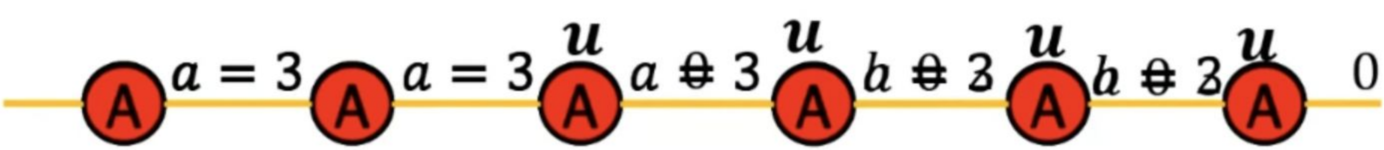
u's decision	v's decision	Payoff
AB	A	a*
AB	B	b*
AB	AB	$max(a, b)$

Payoff for a multiple choice decision model
* a and b are positive constants

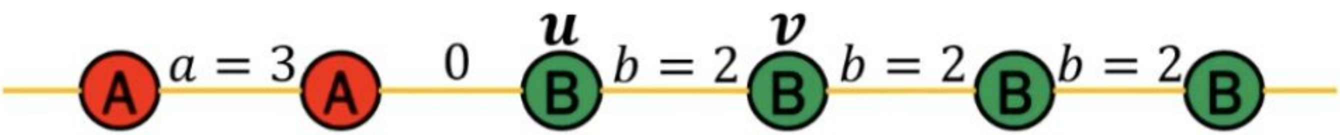
Cascades for Infinite Chain Networks: Single Choice



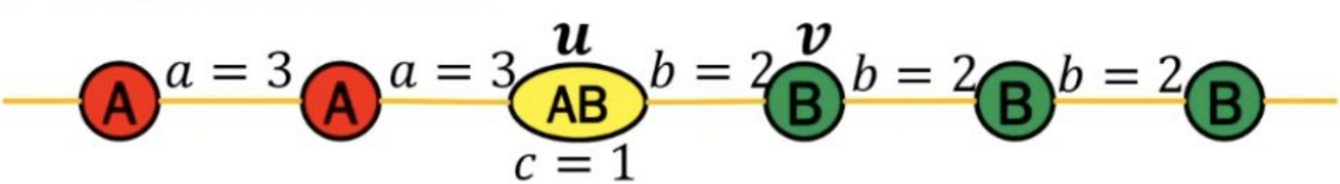
- Consider the case: $a = 3, b = 2$
- Two possible choice for node u
  - Stick with strategy B, total payoff: 0 + 2 = 2
  - Switch to strategy A, total payoff: **3 + 0 = 3**
- So, node u would adopt strategy A
- And the cascade continues…



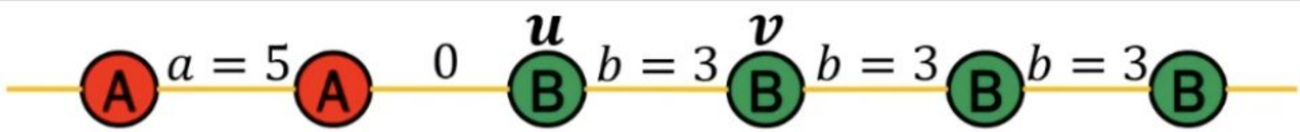
Cascades for Infinite Chain Networks: Multiple Choice: Case I



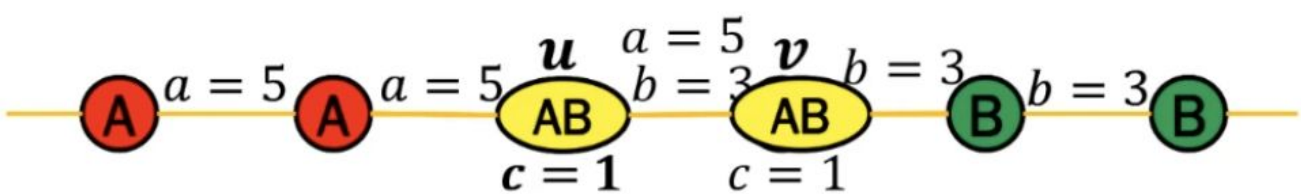
- Consider the case: $a = 3, b = 2, c = 1$
- Two possible choice for node u
  - Stick with strategy B, total payoff: 0 + 2 = 2
  - Switch to strategy A, total payoff: 3 + 0 = 3
  - Switch to strategy AB, total payoff: **3 + 2 – 1 = 4**
- So, node u would adopt strategy AB
- And system is stable now!!



Cascades for Infinite Chain Networks: Multiple Choice: Case II

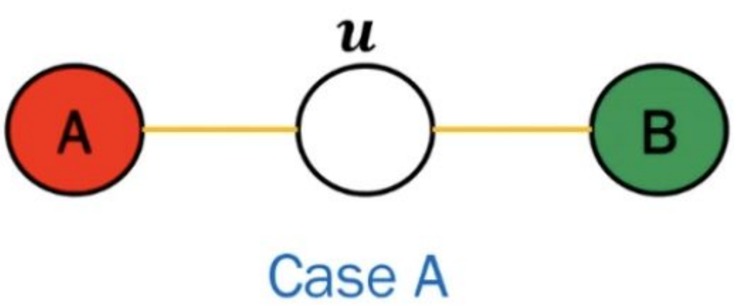


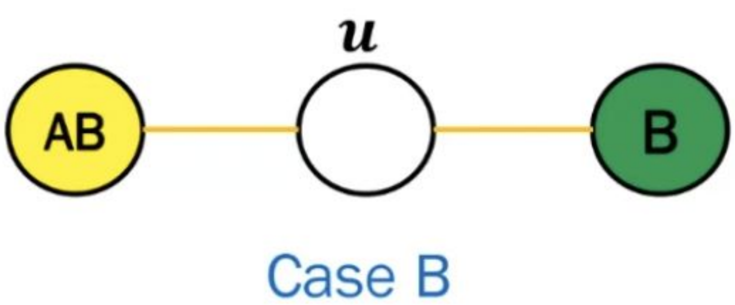
- Consider the case: $a = 5, b = 3, c = 1$
- Two possible choices for node u
  - Stick with strategy B, total payoff: 0 + 3 = 3
  - Switch to strategy A, total payoff: 5 + 0 = 5
  - Switch to strategy AB, total payoff: **5 + 3 – 1 = 7**
- So, node u would adopt strategy AB
- Two possible choices for node v
  - Stick with strategy B, total payoff: 3 + 3 = 6
  - Switch to strategy A, total payoff: 5 + 0 = 5
  - Switch to strategy AB, total payoff: **5 + 3 – 1 = 7**
- So, node v would adopt strategy AB
- And the cascade continues!!



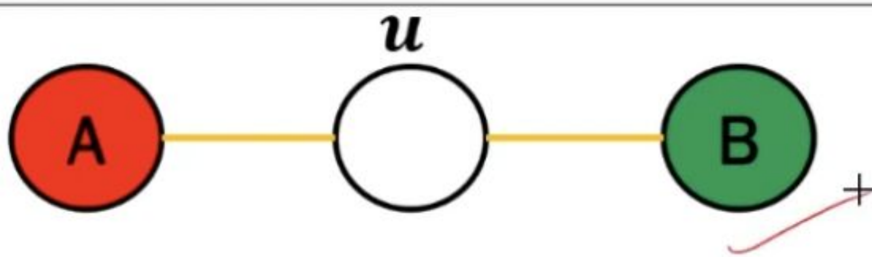
Cascade in Infinite Chain Networks: Generic Model

- Let us consider an infinite chain network with strategy set $\{A, B, AB\}$
- We consider the scenario: $a = a, b = 1, c = c$
- Two possible cases may arise:





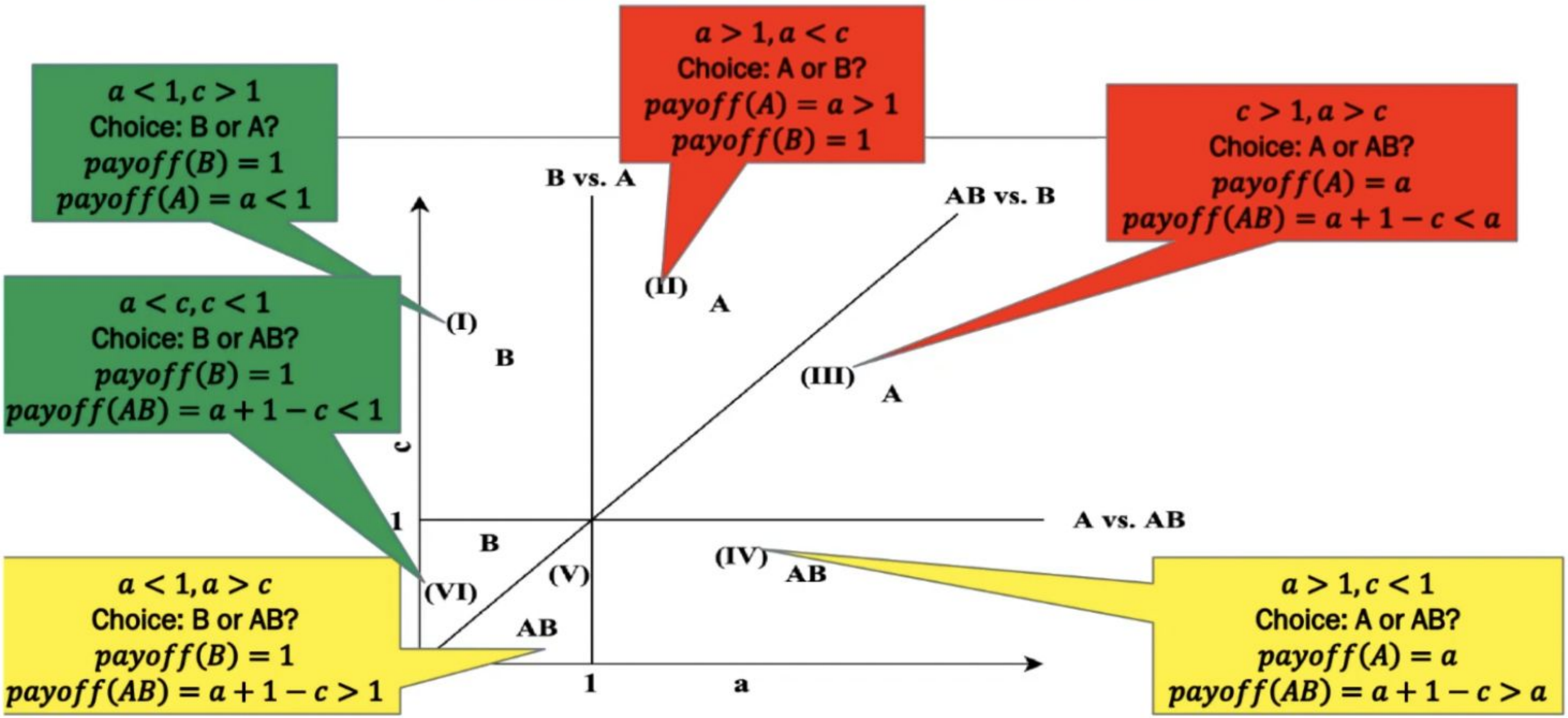
Generic Model: Case A



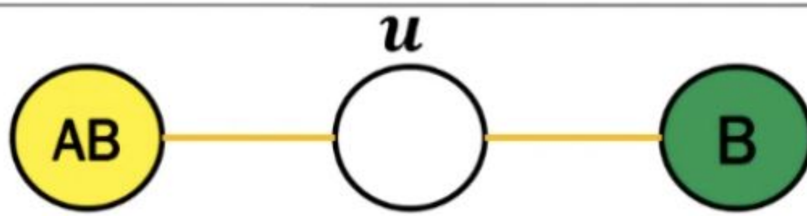
- Three possible options for node u
  1. Adopt Behavior A; Payoff $= a + 0 = a$
  2. Adopt Behavior B; Payoff $= 0 + 1 = 1$
  3. Adopt Behavior AB; Payoff $= a + 1 - c$

- Breakpoint Equations:
  a. B versus A: $a = 1, a < 1$: Prefer strategy B; $a > 1$: Prefer strategy A
  b. AB versus B: $a = c, a < c$: Prefer strategy B; $a > c$: Prefer strategy AB
  c. A versus AB: $c = 1, c < 1$: Prefer strategy AB; $c > 1$: Prefer strategy A

Generic Model: Case A



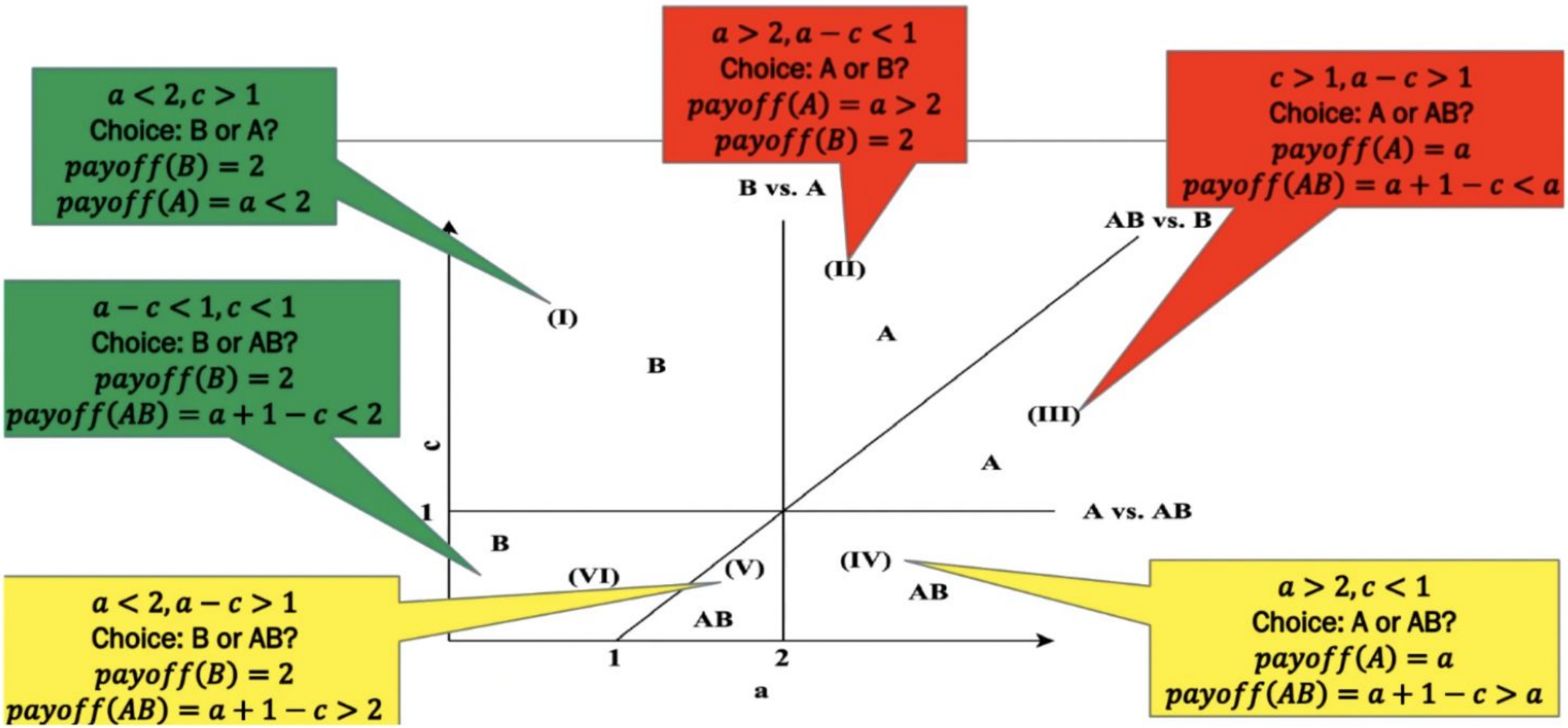
Generic Model: Case B



- Three possible options for node u
  1. Adopt Behavior A; Payoff $= a + 0 = a$
  2. Adopt Behavior B; Payoff $= 1 + 1 = 2$
  3. Adopt Behavior AB; Payoff $= a + 1 - c$, if $max(a, 1) = a$

- Breakpoint Equations:
  a. B versus A: $a = 2, a < 2$: Prefer strategy B; $a > 2$: Prefer strategy A
  b. AB versus B: $a - c = 1, a - c < 1$: Prefer strategy B; $a - c > 1$: Prefer strategy AB
  c. A versus AB: $c = 1, c < 1$: Prefer strategy AB; $c > 1$: Prefer strategy A

Generic Model: Case B



Generic Model: Combined