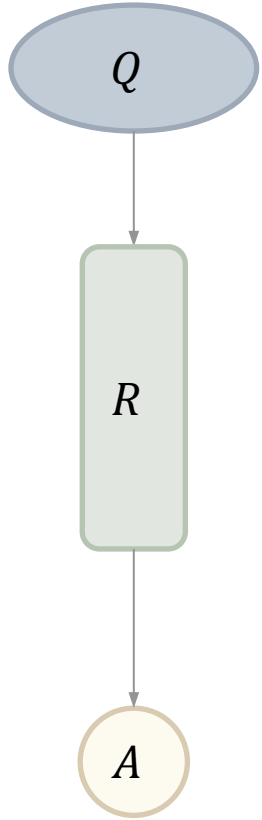# Exchange-of-Thought: Enhancing Large Language Model Capabilities through Cross-Model Communication

Zhangyue Yin, Qiushi Sun, Cheng Chang
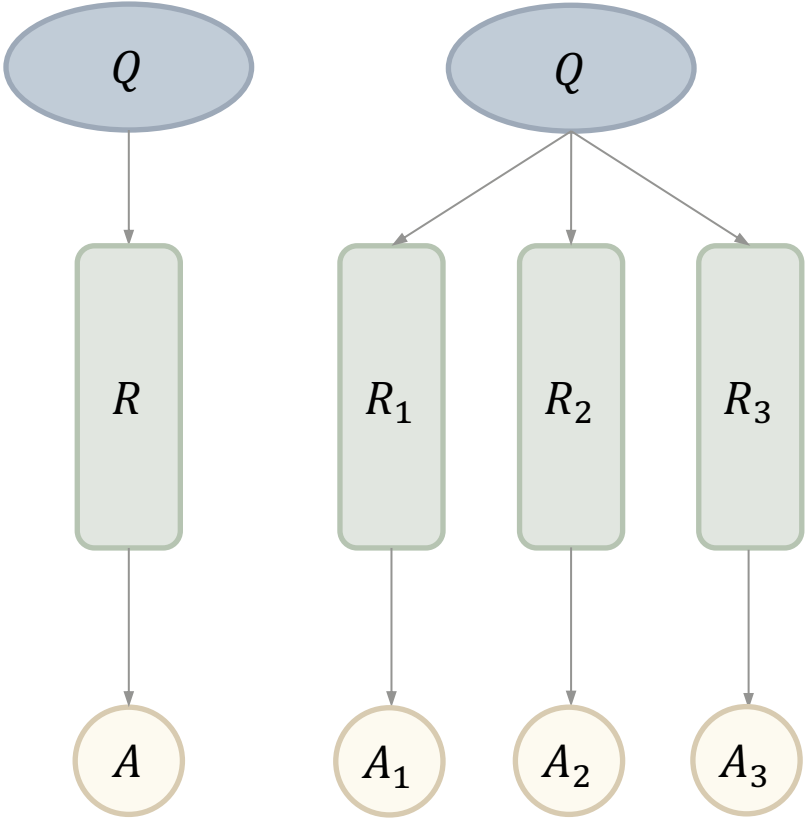Qipeng Guo, Junqi Dai, Xuanjing Huang, Xipeng Qiu
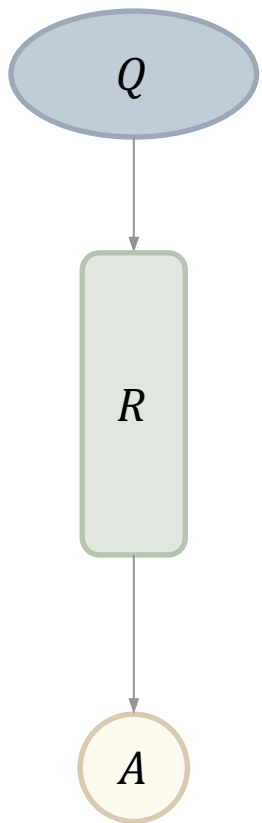
Q

R

A

(a) CoT

Background: Self-Consistency

(a) CoT   (b) Self-Consistency

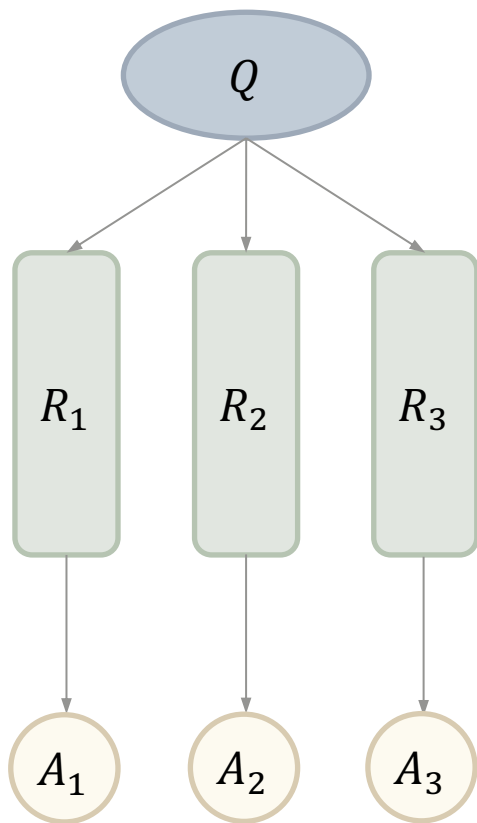(a) CoT (b) Self-Consistency (c) Self-Correction

(a) CoT   (b) Self-Consistency   (c) Self-Correction
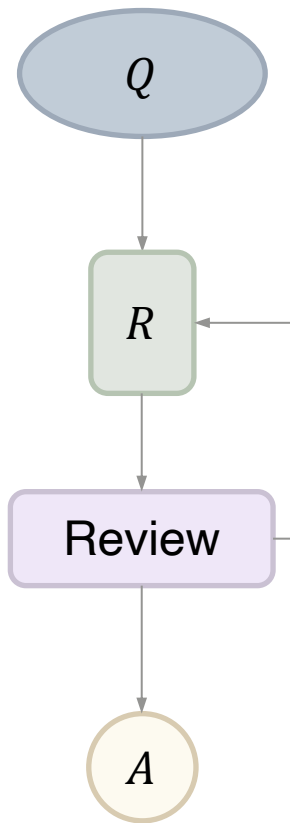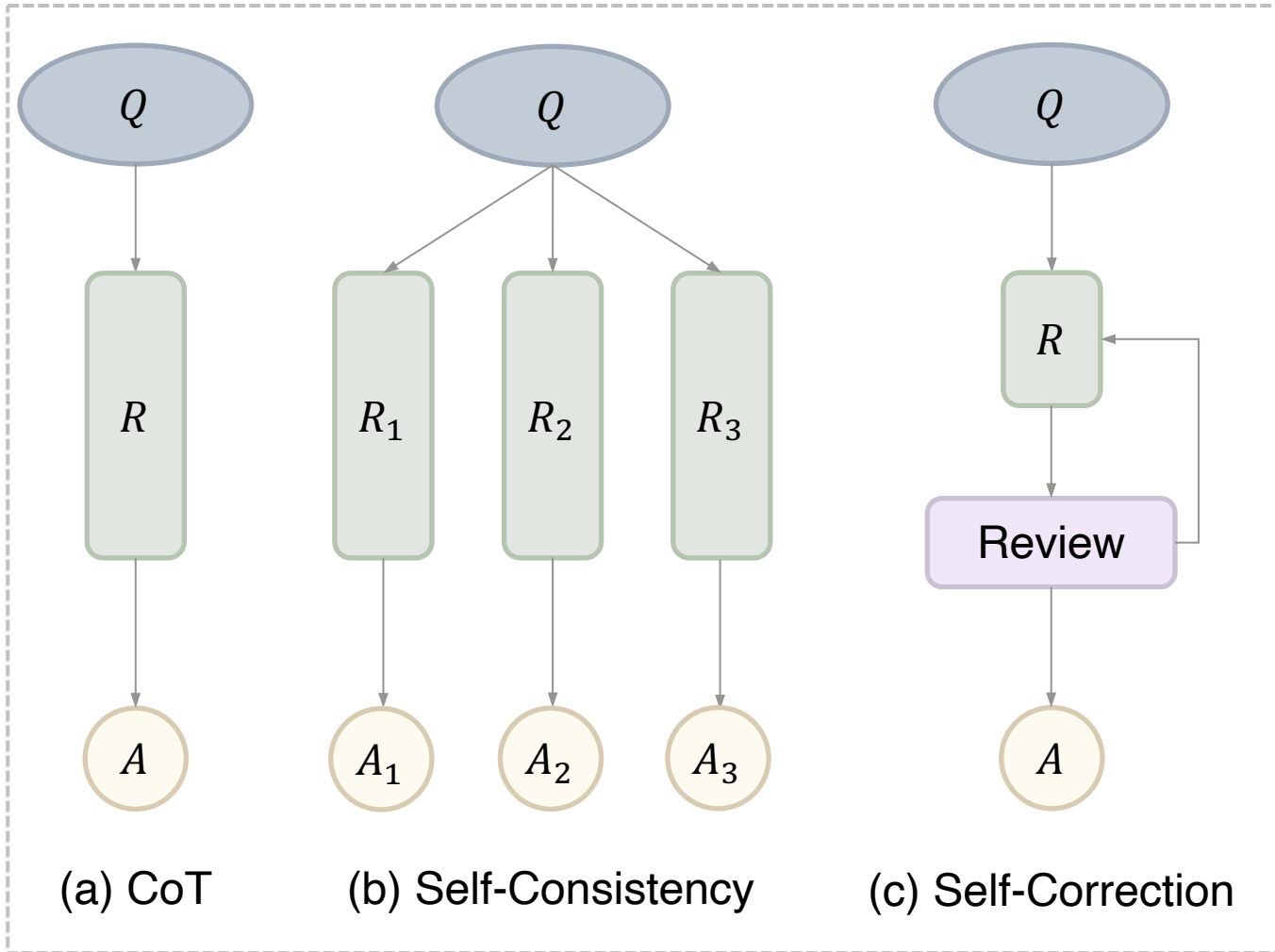
No External Insights

Q: Twenty dozen cups cost \$1200 less than the total cost of half a dozen plates sold at \$6000 each. Calculate the total cost of buying each cup.

R_1: The cost of half a dozen plates is 6/2 x 6000 = \$18,000. Twenty dozen cups is 20 x 12 = 240 …X= 70 Therefore, the total cost of buying each cup is \$70. ✗

R_2: Firstly, we need to convert 20 dozen into a total number of cups. One dozen is equal to 12, so 20 dozen is equal to 20 x 12 = 240 cups…To solve for x, we divide both sides by 240: x = \$145 So the total cost of buying each cup is \$145. ✓

R_3: First, we need to convert twenty dozen cups to regular cups, which is 20 x 12 = 240 cups…, we need to divide the total cost by the number of cups: \$16800 / 240 cups = \$70 per cup. So the answer is \$70. ✗

Hard Problem from GSM8K
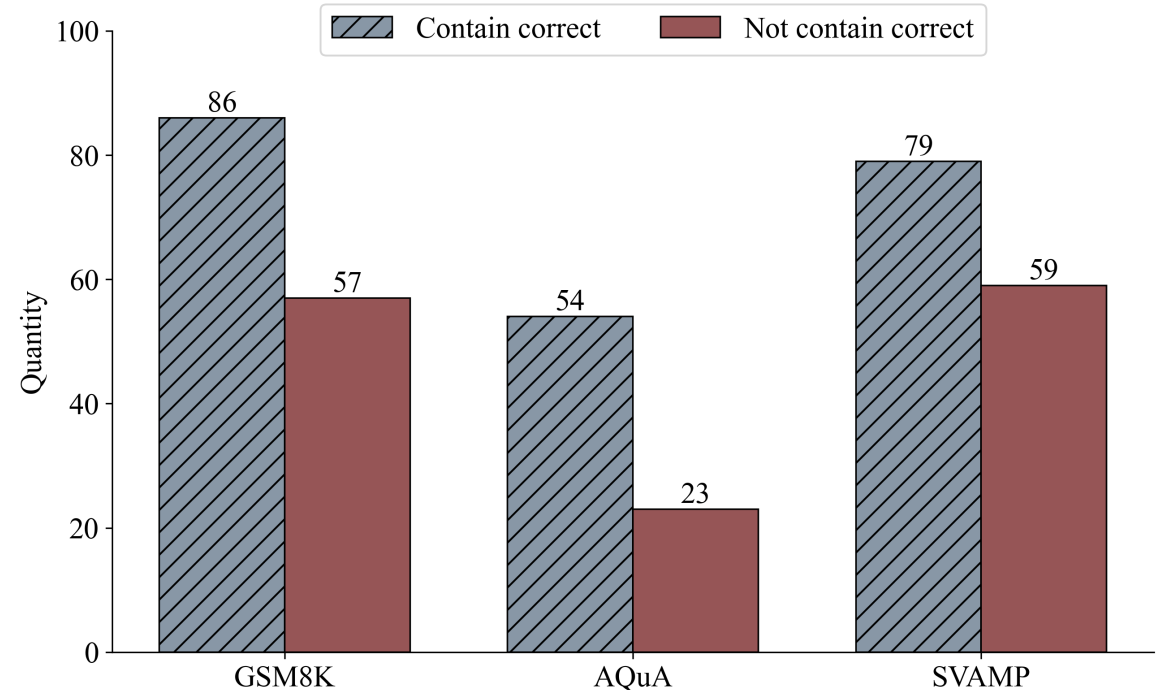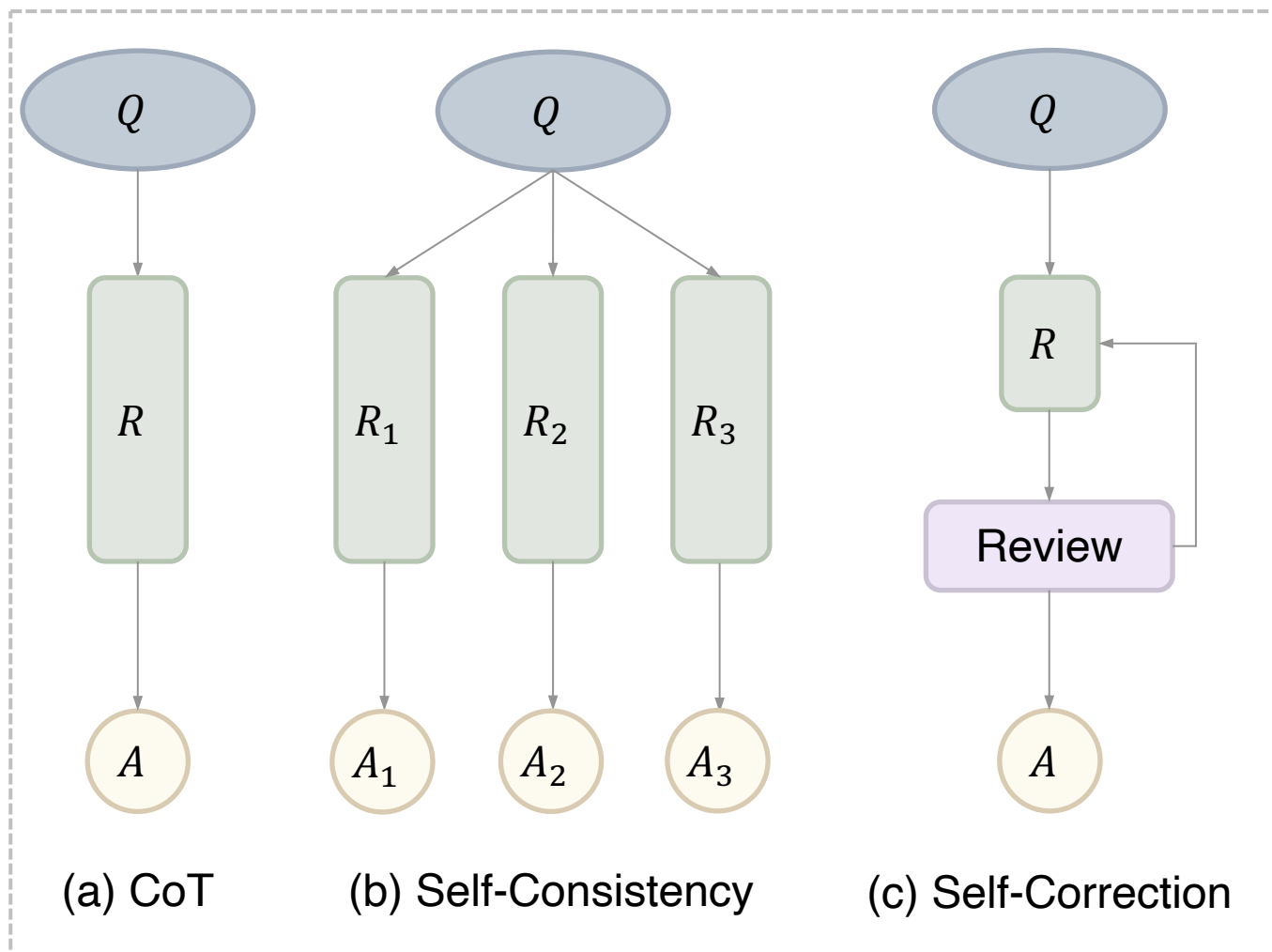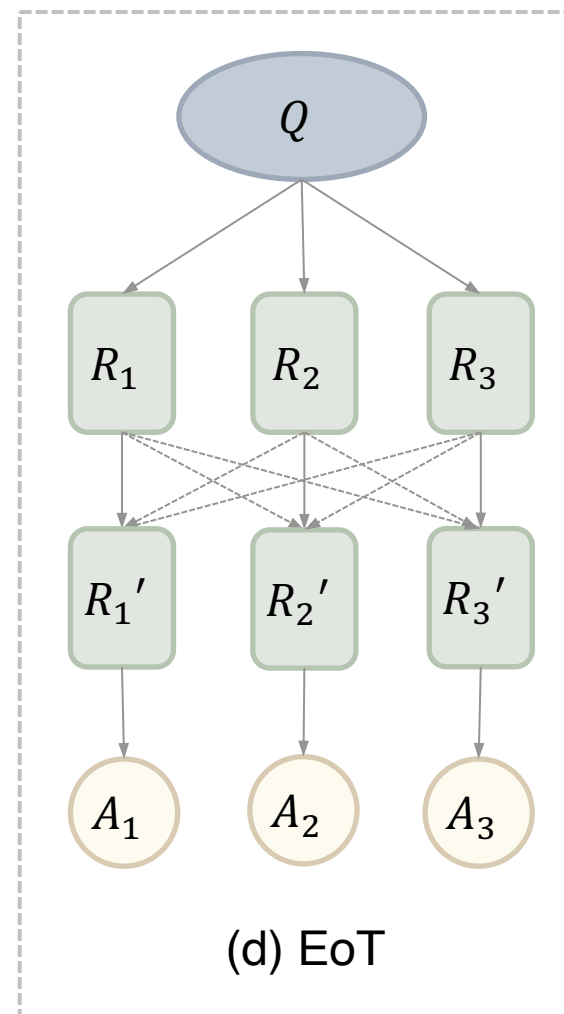
The number of error samples that contain and not contain the correct answer

(a) CoT

(b) Self-Consistency

(c) Self-Correction

(d) EoT

No External Insights

External Insights

"You are Ben, a high school student with a track record of excellent grades, particularly in mathematics. Your friends admire your diligence and often seek your guidance in their studies. … After considering your friends' approaches, carefully construct your answer, ensuring to clarify each step of your process."

"You are Peter, a high school student recognized for your unique problem-solving abilities. Your peers often turn to you for assistance when they encounter challenging tasks, as they appreciate your knack for devising creative solutions… Once you've crafted your solution, share it with your friends, so they can see a different perspective."
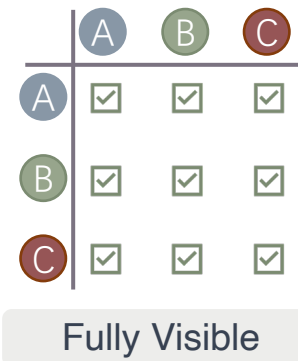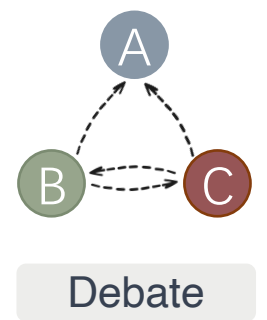
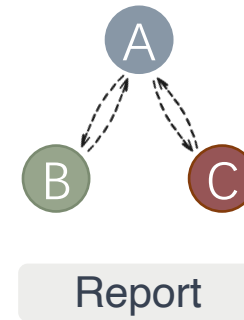"You are Kitty, a high school student admired for your attentiveness and detail-oriented nature. Your friends often rely on you to catch details they might have missed in their work… Your careful revisions will help all of you to enhance your understanding and arrive at the most accurate solutions possible."

EoT: Communication Mode

Drawing inspiration from network topology, we proposed several ways of information.

□ Memory: All thoughts will be shared in the Memory.

□ Report: All thoughts will be aggregated to a central node.
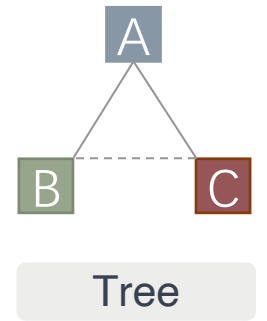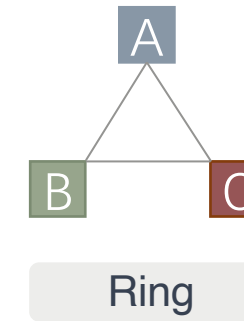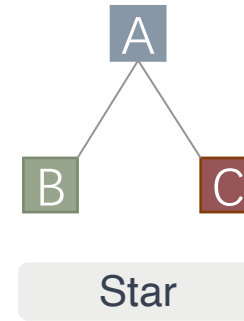
□ Relay: All thoughts will be passed among neighbors.

□ Debate: The thoughts will be passed to the child nodes and aggregated at the parent node.

Bus   Star   Ring   Tree

Memory   Report   Relay   Debate

Fully Visible   Central Visible   Neighbor Visible   Peers Visible
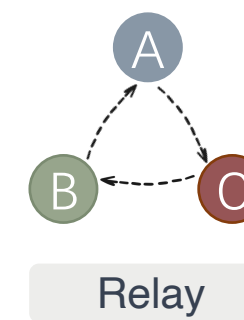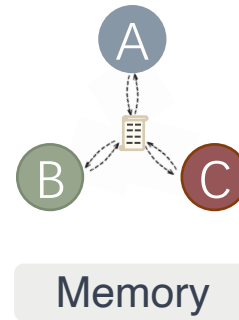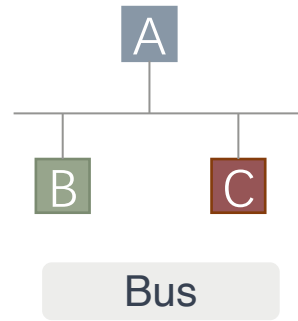
Confidence Evaluation: Evaluating the confidence by observing the changes in answers during the communication process.
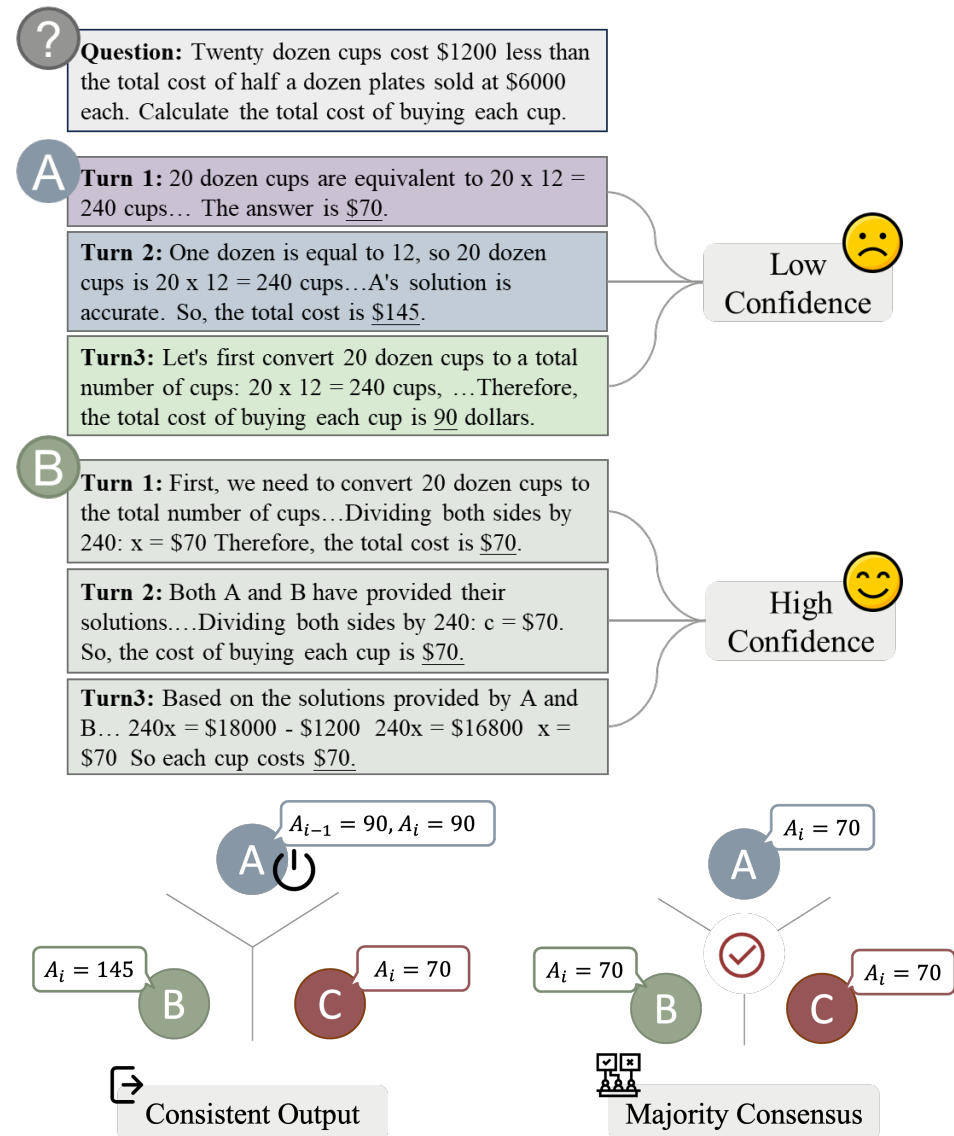
❑ Low confidence: Frequently changing the answer.
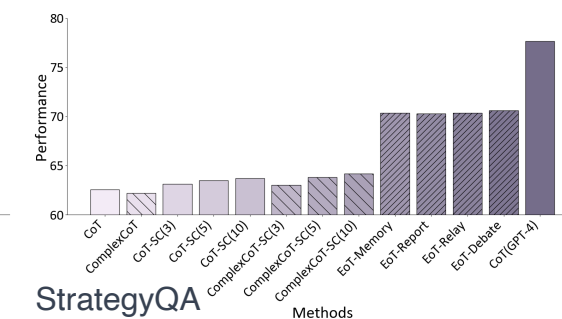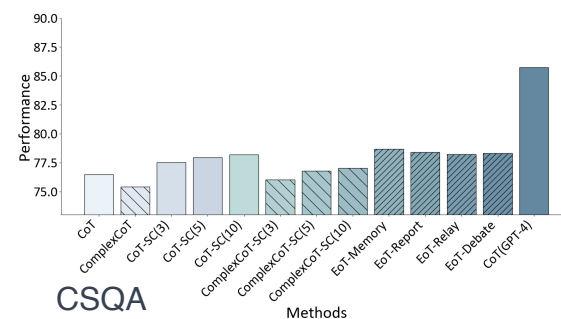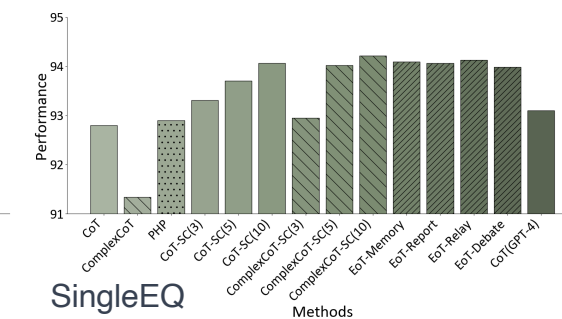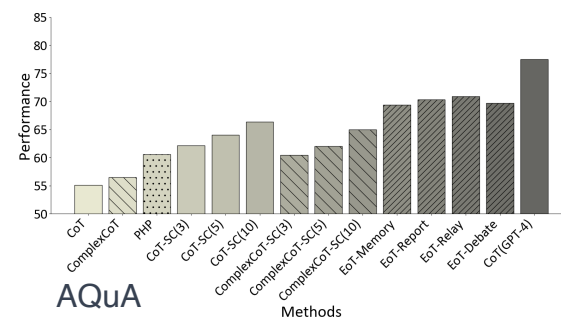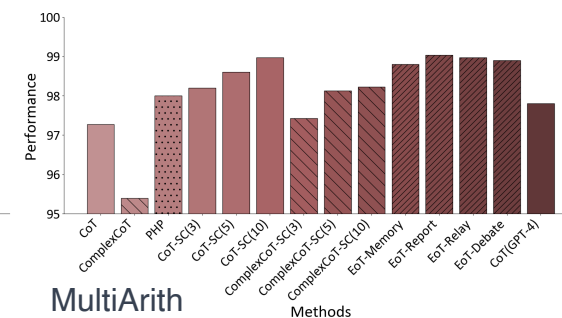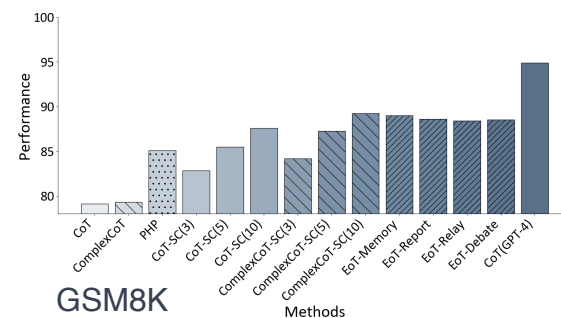
❑ High confidence: Sticking to one answer.

Termination Condition: Stopping criteria for model communication.

❑ Consistent Output: Model exits the communication when its outputs are consistent between two consecutive interactions.

❑ Majority Consensus: Terminate when the majority of models reach a consensus on the answer.

? **Question:** Twenty dozen cups cost $1200 less than the total cost of half a dozen plates sold at $6000 each. Calculate the total cost of buying each cup.

A **Turn 1:** 20 dozen cups are equivalent to 20 x 12 = 240 cups... The answer is $70.

Turn 2: One dozen is equal to 12, so 20 dozen cups is 20 x 12 = 240 cups...A's solution is accurate. So, the total cost is $145.

Turn3: Let's first convert 20 dozen cups to a total number of cups: 20 x 12 = 240 cups, ...Therefore, the total cost of buying each cup is 90 dollars.

Low Confidence ☹

B **Turn 1:** First, we need to convert 20 dozen cups to the total number of cups...Dividing both sides by 240: x = $70 Therefore, the total cost is $70.

Turn 2: Both A and B have provided their solutions....Dividing both sides by 240: c = $70. So, the cost of buying each cup is $70.

Turn3: Based on the solutions provided by A and B... 240x = $18000 - $1200 240x = $16800 x = $70 So each cup costs $70.

High Confidence ☺

$A_{i-1} = 90, A_i = 90$

A ⏻

$A_i = 145$ **B**   **C** $A_i = 70$

→ Consistent Output

$A_i = 70$

A

$A_i = 70$ **B** ✓ **C** $A_i = 70$

Majority Consensus

❑ EoT significantly outperforms the Self-Consistency method in mathematical reasoning tasks.
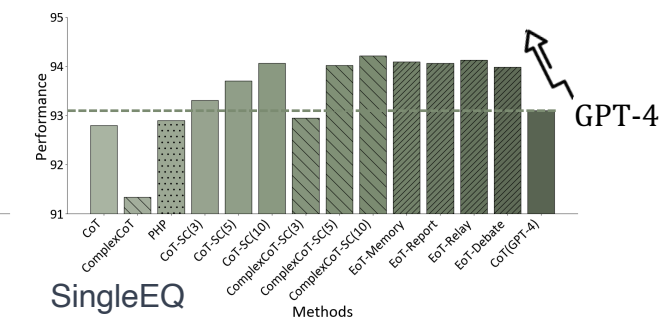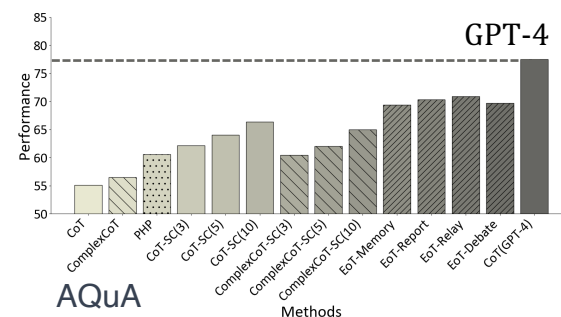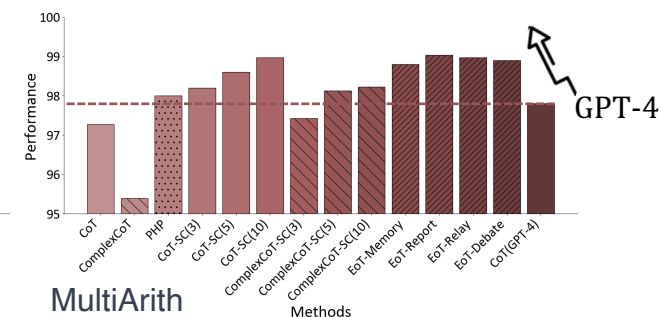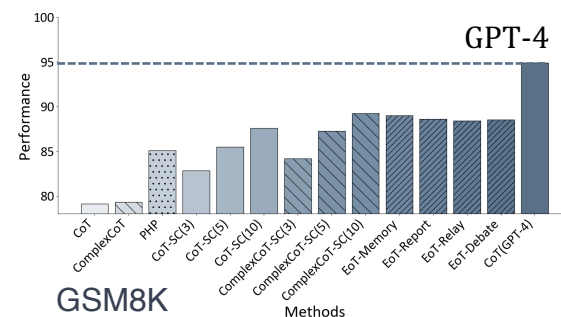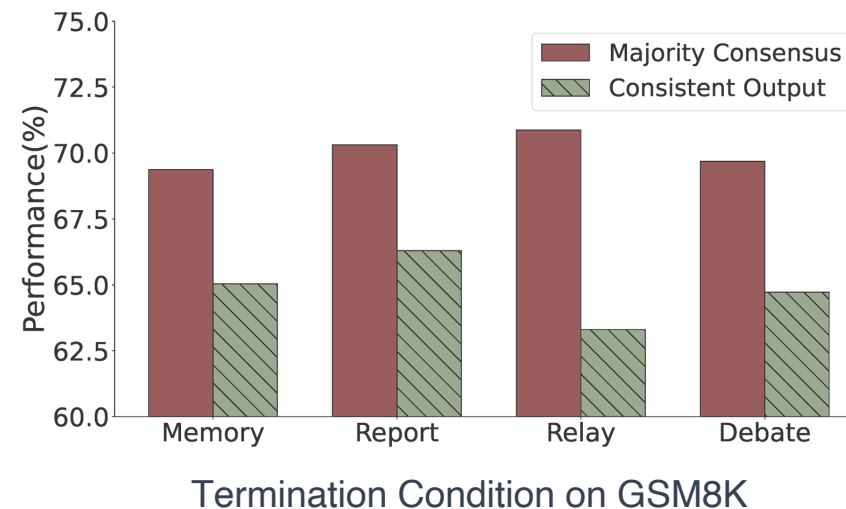
Experiment Results

❑ EoT significantly outperforms the Self-Consistency method in mathematical reasoning tasks.

❑ On the MultiArith and SingleEQ datasets, three GPT-3.5 models using the EoT method surpassed the performance of a single GPT-4 using the CoT method.

❑ Two heads are better than one!
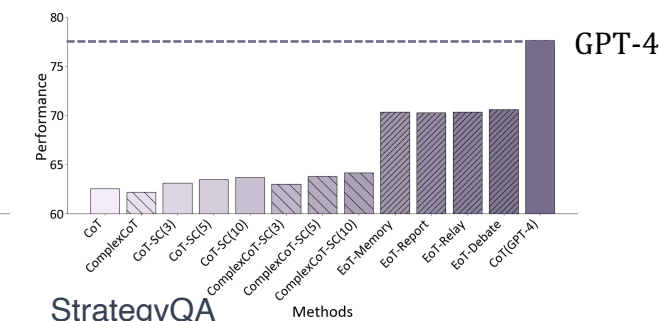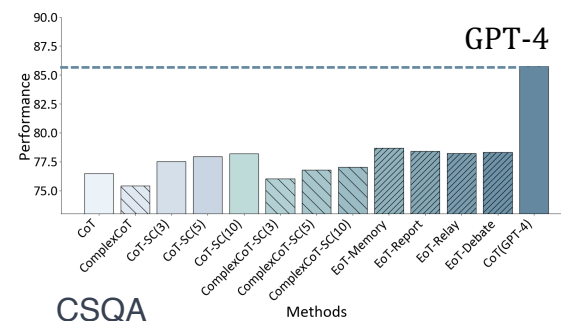
Analysis

Termination Condition Analysis

❑ Consistent Output: solely relies on the consistency of answers generated by a single model.

❑ Majority Consensus: relies on the consistency of answers from all participating models. (Better performance !)

Termination Condition on GSM8K

Termination Condition Analysis

- ❑ Consistent Output: solely relies on the consistency of answers generated by a single model.

- ❑ Majority Consensus: relies on the consistency of answers from all participating models. (Better performance !)
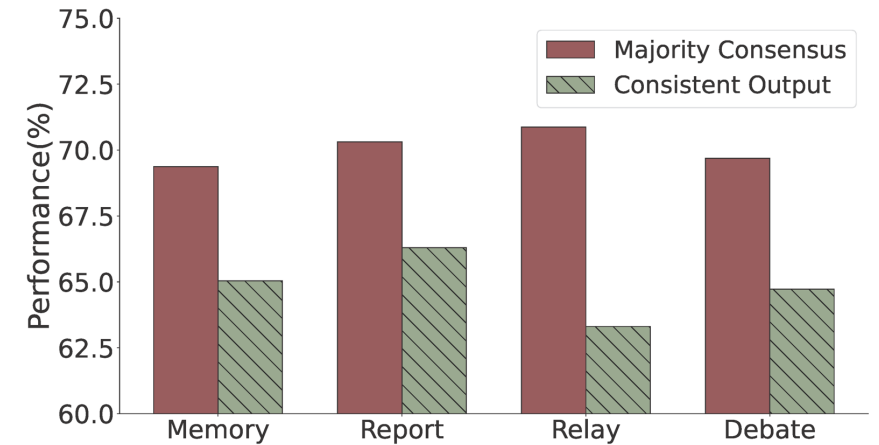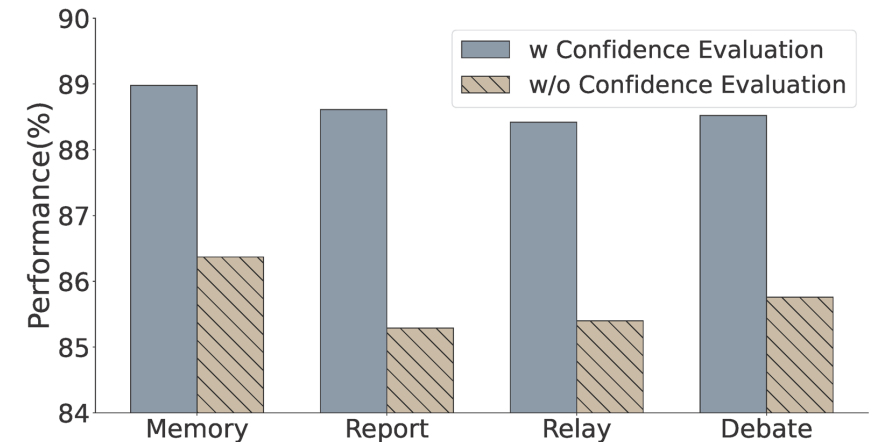
Confidence Evaluation Analysis

- ❑ No Confidence Evaluation: lacks prior on content reliability and is easily susceptible to interference.

- ❑ With Confidence Evaluation: During communication, consider the confidence prior of other models to eliminate interference information. (Better performance !)


Termination Condition on GSM8K

Confidence Evaluation on AQuA

Cost-Effectiveness
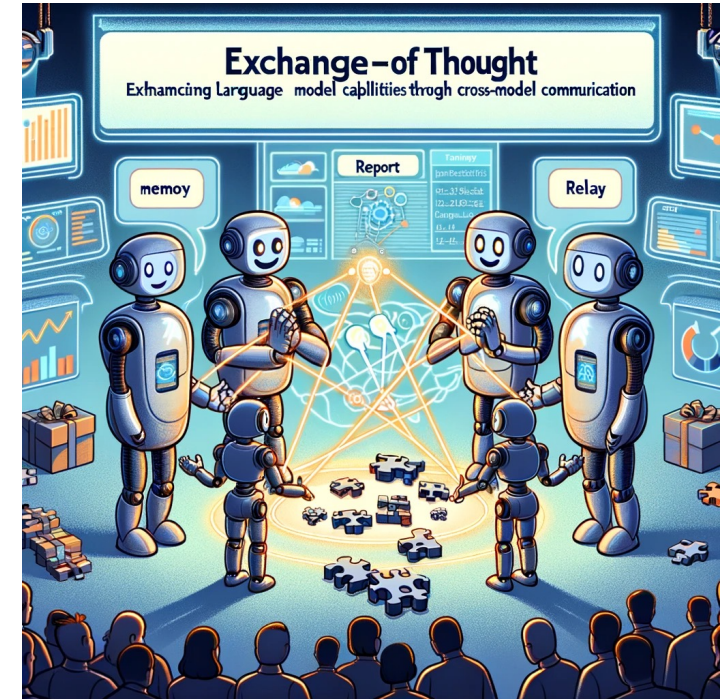
EoT method achieves better performance at a lower cost.

❑ Compared to CoT-SC(5), EoT improved performance by 3% while reducing costs by 20%.

❑ Compared to CoT-SC(10), EoT achieved comparable performance while reducing costs by 60%.

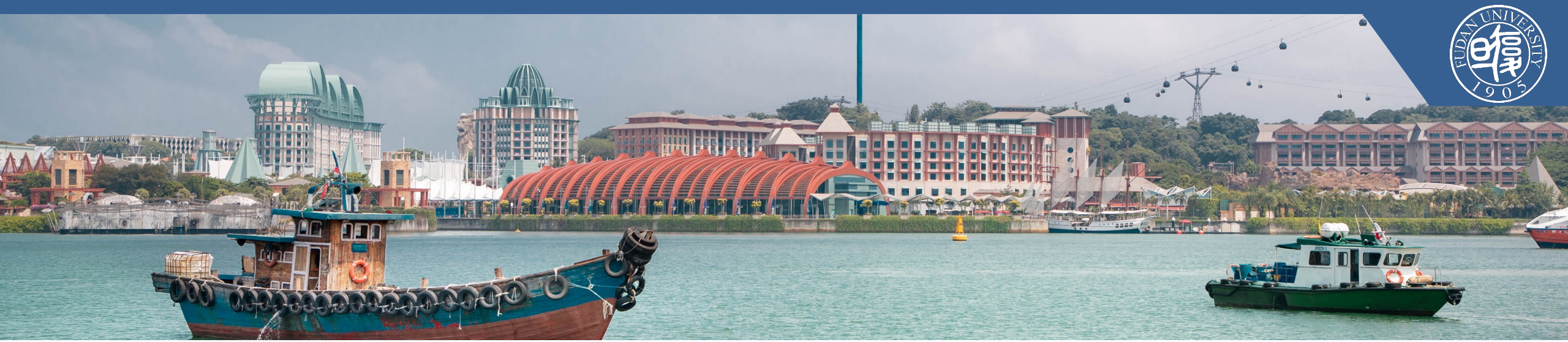❑ Compared to the Self-Consistency method, EoT has a significant cost-effectiveness advantage!
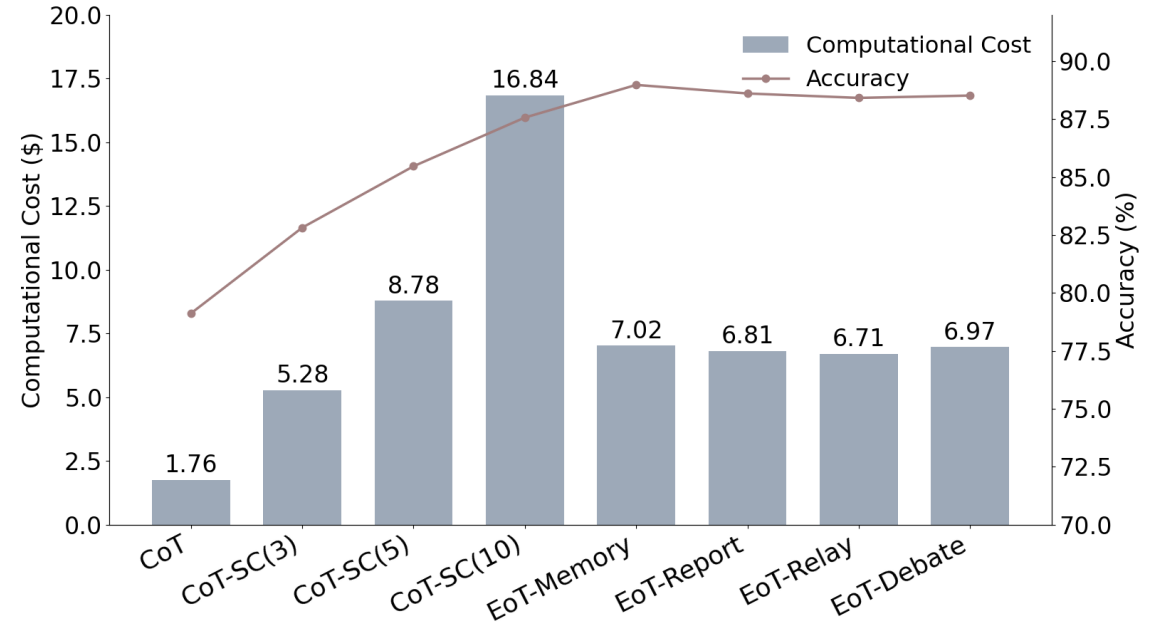
Cost & Performance Analysis on GSM8K

Conclusion

❑ We propose Exchange-of-Thought (EoT), which introduces external insights into the reasoning process through mutual communications.

❑ Inspired by network topology, we introduce four communication modes: Memory, Report, Relay, and Debate, and analyze the communication volume of each mode.

❑ We incorporate a confidence assessment during the reasoning process to minimize the disruption caused by incorrect reasoning.

❑ We design two communication termination conditions: consistent output and majority consensus and evaluated their impact on final performance.

❑ Extensive experiments show that EoT effectively enhances the reasoning capabilities of LLM by introducing external insights and has a cost-effectiveness advantage.

Thank you for watching!