LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

AI IN BIOSYSTEMS AND OHE HEALTH
CHAIR OF FOOD MICROBIOLOGY

Towards AI-assisted Negotiation-Based Risk Analysis



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Overview

- Areas in negotiations to augment with AI
- Pipeline description
- Next steps and further development

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Dusky Seaside Sparrow

- In 1950s marsh habitat was radically altered causing rapid population decline

- When intervention approved, only six males were left.

- Debate about ways to save it took too long.

"...delaying a decision is a decision for extinction" (Gruson, 1981).



Why Human Negotiations Can Fail Under Pressure:

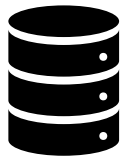
- Speed up negotiations:

Negotiations are time limited.



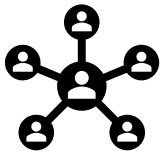
- Integrating big data:

Negotiators need to process immense amount of information



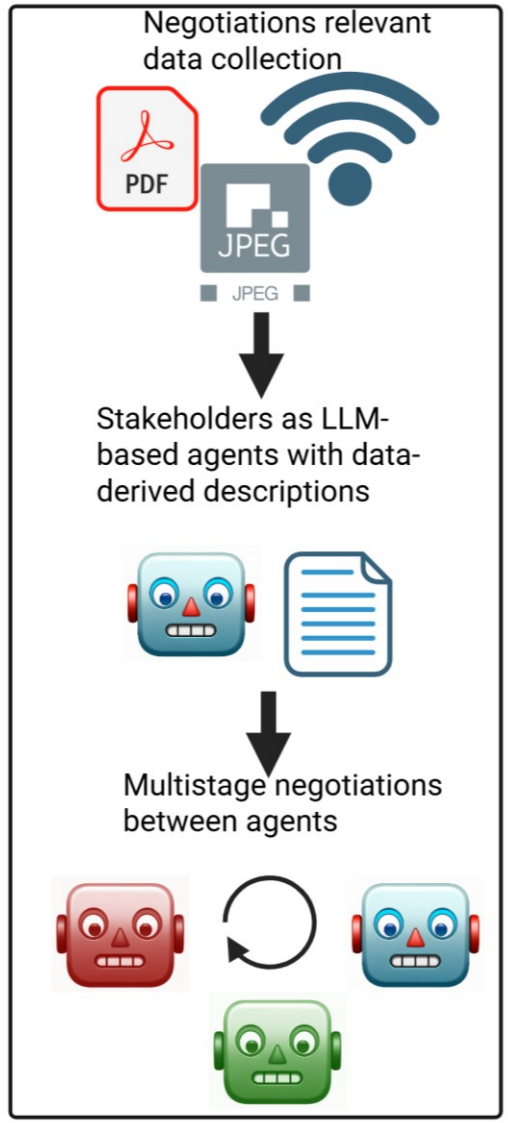
- Limit potential biases:

Negotiators may be biased during information processing



Suggested approach:

- Speed up negotiations
- Integrating big data
- Limit potential biases



Fetsch*, Savvateev* et al., 2025, iScience (under revision)
preprint: https://arxiv.org/abs/2509.09906

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Pipeline description

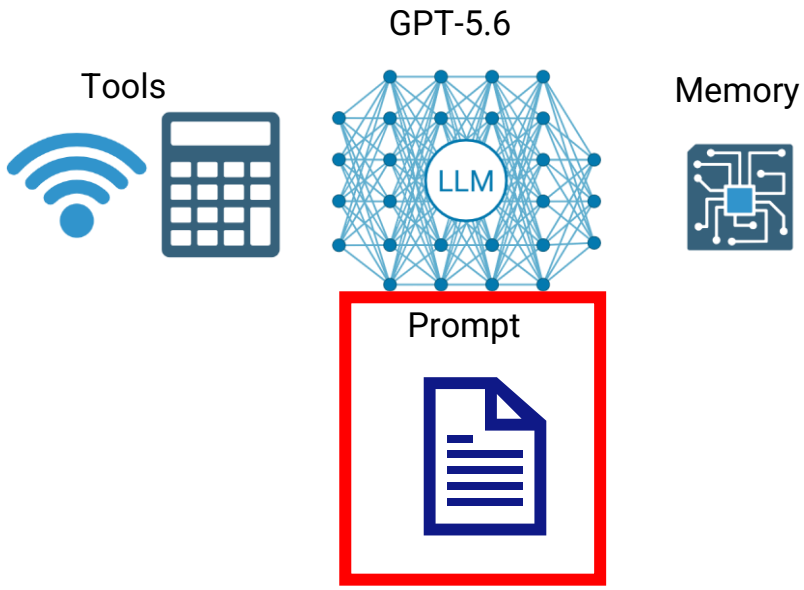




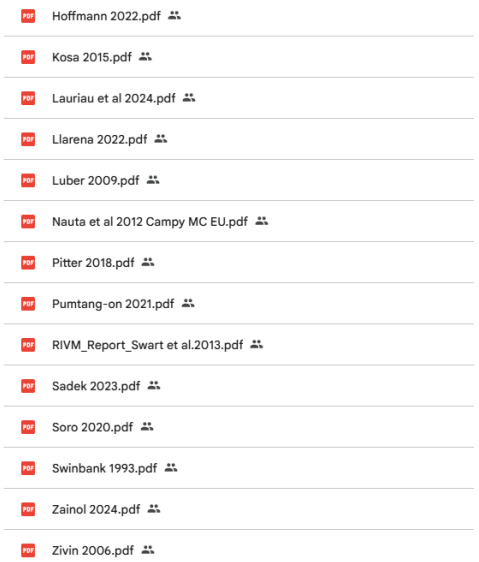
- Two-day workshop on AI-assisted risk negotiation at BfR in 2025
- Experts in food microbiology and risk assessment from academia, government, and industry

Pipeline description : LLM-based agents

LLM-based agent



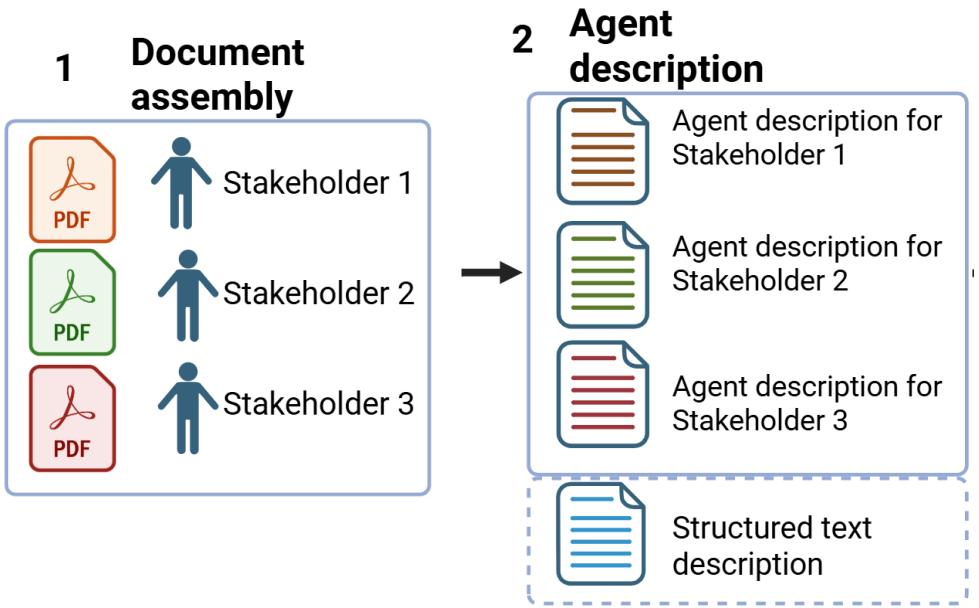
Guo et al., 2024. Light RAG



Stakeholder 1 (Food Industry representative)

Short-term goals
General aim
Scientific foundation
Ethical foundation
References

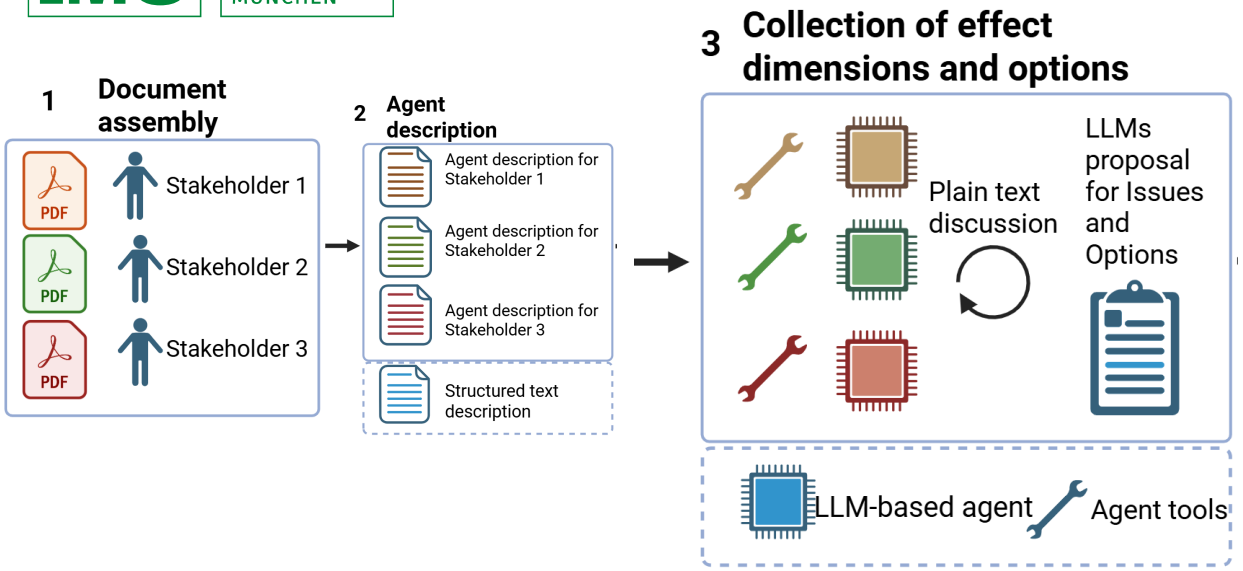
Pipeline description : LLM-based agents



Q3 Where the descriptions used to inform the agents (and shared with you prior to the workshop) representing stakeholders positions?

Answer Choices	Percentage	Responses
not representing at all	0%	0
not representing enough due to lack of significant aspects	5.56%	1
not representing enough due to a large number of minor missing aspects	0%	0
representing enough despite lack of a high number of missing aspects	5.56%	1
representing enough despite minor missing aspects	55.56%	10
comprehensively representing and fit for purpose	33.33%	6

Pipeline description: Preliminary discussion



Broad Topic: How best to balance the trade-offs for setting a food safety microbiological criteria for Campylobacter spp in broiler meat according to the EU legislation No 2073/2005?

Pipeline description: Preliminary discussion

1 Document

2 Agent

3 Collection of effect dimensions and options

```
## Turn 2: Food industry
**Timestamp:** `2026-08-20T12:24:25.715725`

"Should the EU tighten the microbiological criterion for *Campylobacter spp.* in broiler meat under Regulation (EC) No 2073/2005 by lowering the acceptable contamination limit and/or increasing sampling requirements even if this raises production costs and may affect meat prices, availability, environmental impacts, and consumer choice?"

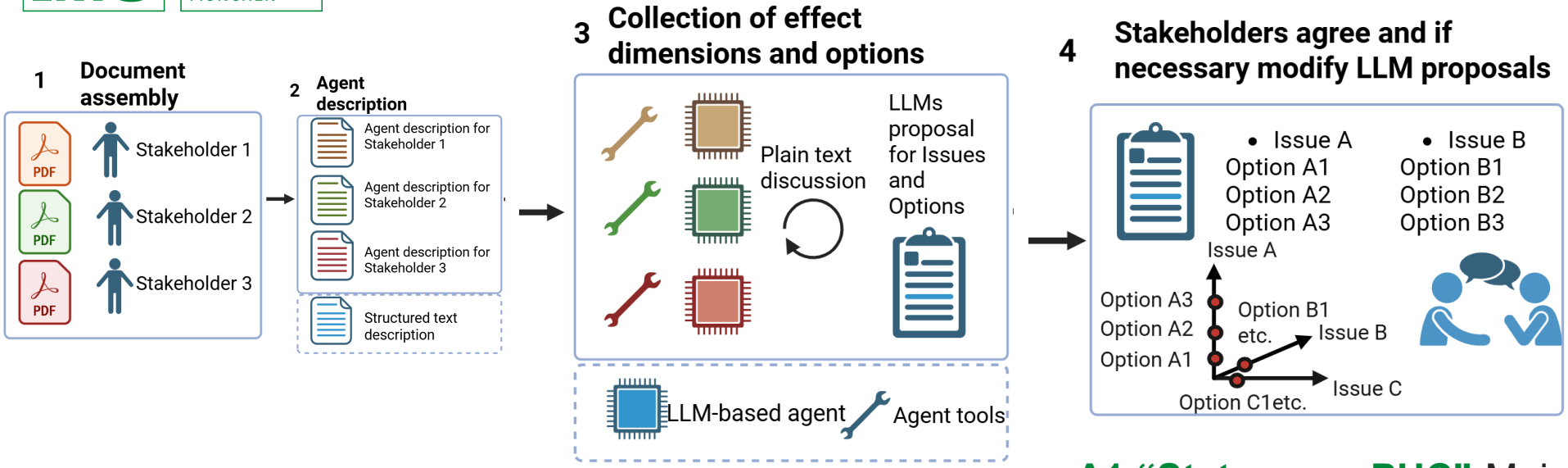
Our answer as the food industry is: **yes to tighter risk reduction, but not to an abrupt shift that turns a process-control tool into a de facto batch-destruction system without validated mitigation pathways.** Using the RAKIP FSKX metadata tool, I checked the two suggested models: model **22190e40-6fee-4838-8465-87e0a165f218** evaluates a Campylobacter **Process Hygiene Criterion at 1,000 CFU/g with 5 samples per batch**, estimating public-health benefit and producer impact; model **0350c3fc-7665-4504-9c77-e4aff2b77126** evaluates EU-style sampling plans, including default **n=50, c=10, m=1,000 CFU/g**, and even assigns an illness cost of **€3,001.82 per case**, showing why prevention has real societal value.

I also used DuckDuckGo to check recent EU evidence: the EFSA/ECDC 2023 One Health report notes that, among official-control broiler meat samples, **16.0% exceeded 1,000 CFU/g**, confirming that Campylobacter remains a serious operational and public-health issue. We therefore accept the ethical obligation to reduce contamination through farm biosecurity, validated pre-harvest tools, slaughter hygiene, quantitative testing, and post-processing hurdles.

Where we would challenge authorities or consumer groups is on proportionality: lowering limits without allowing diversion, heat treatment, targeted decontamination, or dynamic shelf-life tools risks unnecessary food waste, higher prices, and reduced availability, while not necessarily maximizing illness reduction per euro spent.

**Proposal: phase in stricter Campylobacter criteria over 3–5 years, tied to EU-supported batch-level risk assessment, harmonized sampling, validated intervention options, and waste-minimizing diversion routes for non-compliant lots.**
```

Pipeline description: Preliminary discussion




```
**Broad Topic:**
How best to balance the trade-offs for
setting a food safety microbiological criteria
for Campylobacter spp in broiler meat according
to the EU legislation No 2073/2005?
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Issue A: Stringency of process Hygiene Criterion (PHC) vs Food Safety Criterion (FSC)

Issue B:Cost burden sharing

Issue C:Type of rule: uniform EU vs tailored etc.

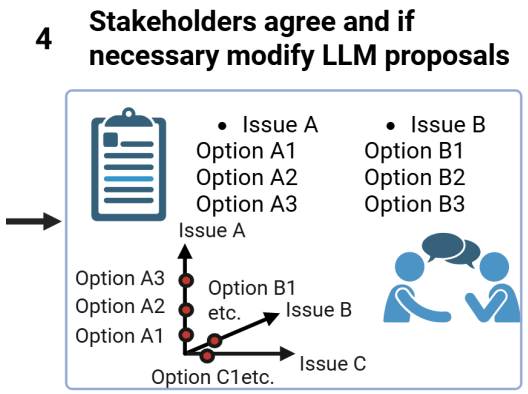
A1 "Status quo PHC": Maintain the existing PHC only (no FSC).

A2 "Phased FSC (lenient limit): Introduce an FSC phased in gradually with risk-based sampling.

A3 "Strict FSC": Adopt a stringent FSC with a low limit and immediate withdrawal or recall of non-compliant batches to maximize public health protection.

Pipeline description: Preliminary discussion

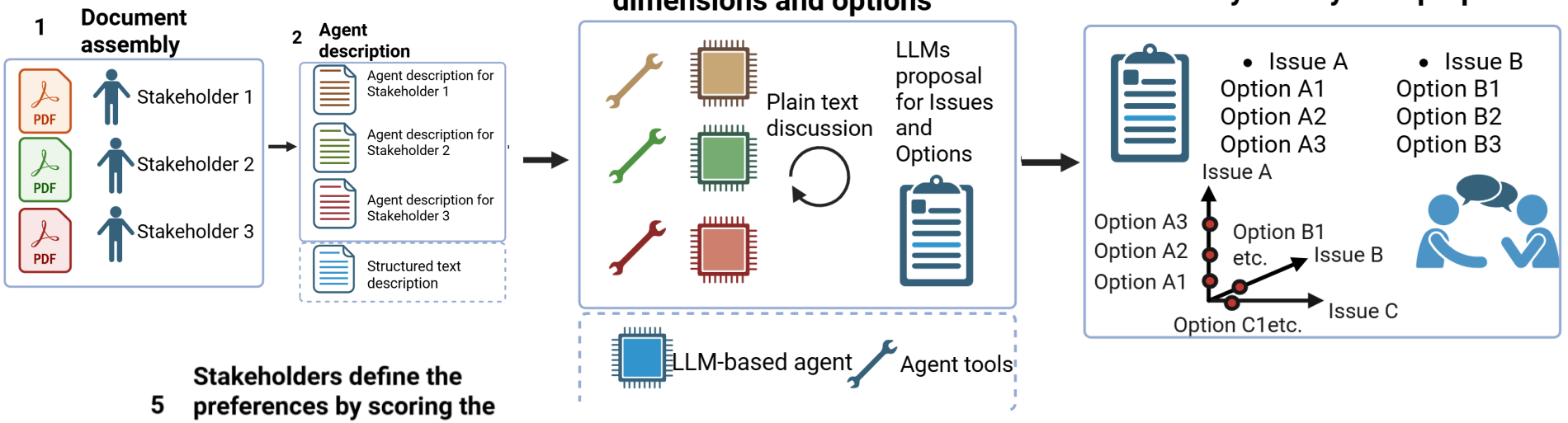


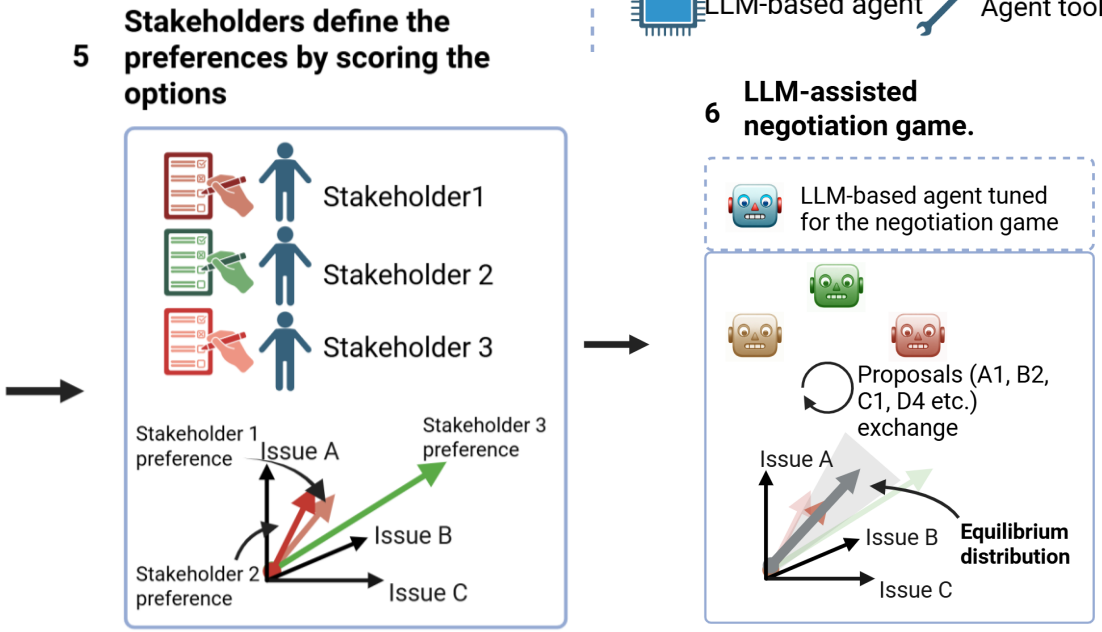


Q4 Did the initially proposed issues-options (results of preliminary negotiation) addressed the trade-offs to be considered during the negotiation?

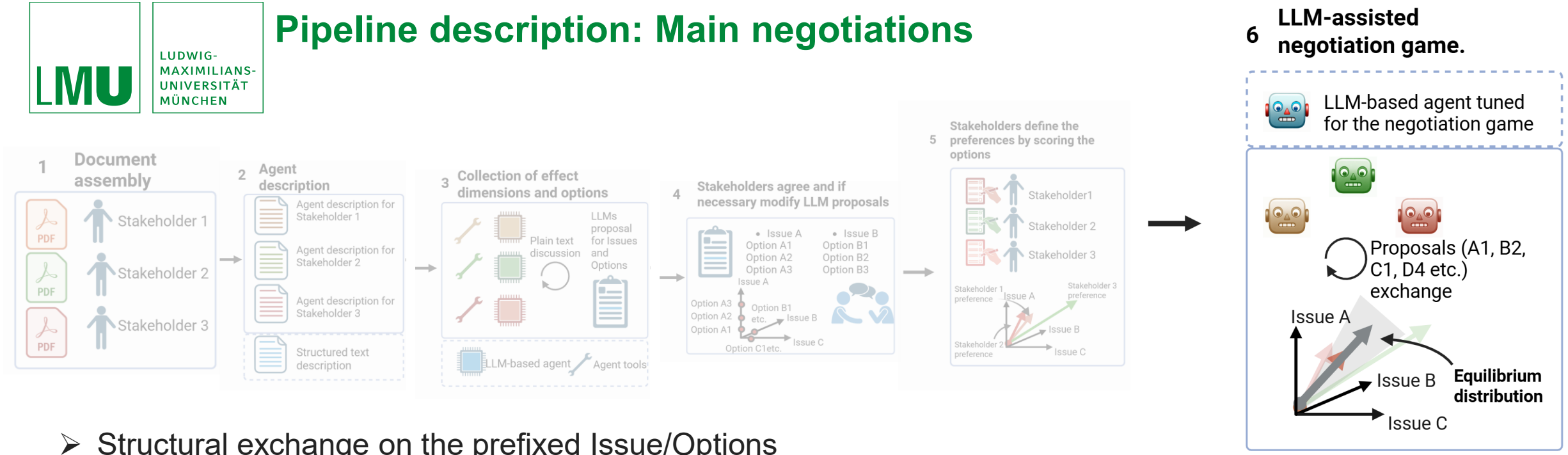
Answer Choices	Percentage	Responses
not addressing at all	0%	0
not addressing enough due to lack of significant aspects	11.11%	2
not addressing enough due to a large number of minor missing aspects	0%	0
addressing enough despite lack of a high number of missing aspects	5.56%	1
addressing enough despite minor missing aspects	77.78%	14
comprehensively addressing and fit for purpose	5.56%	1

Pipeline description: Main negotiations





Pipeline description: Main negotiations



- Structural exchange on the prefixed Issue/Options

I suggest A2, B4, C2,…?

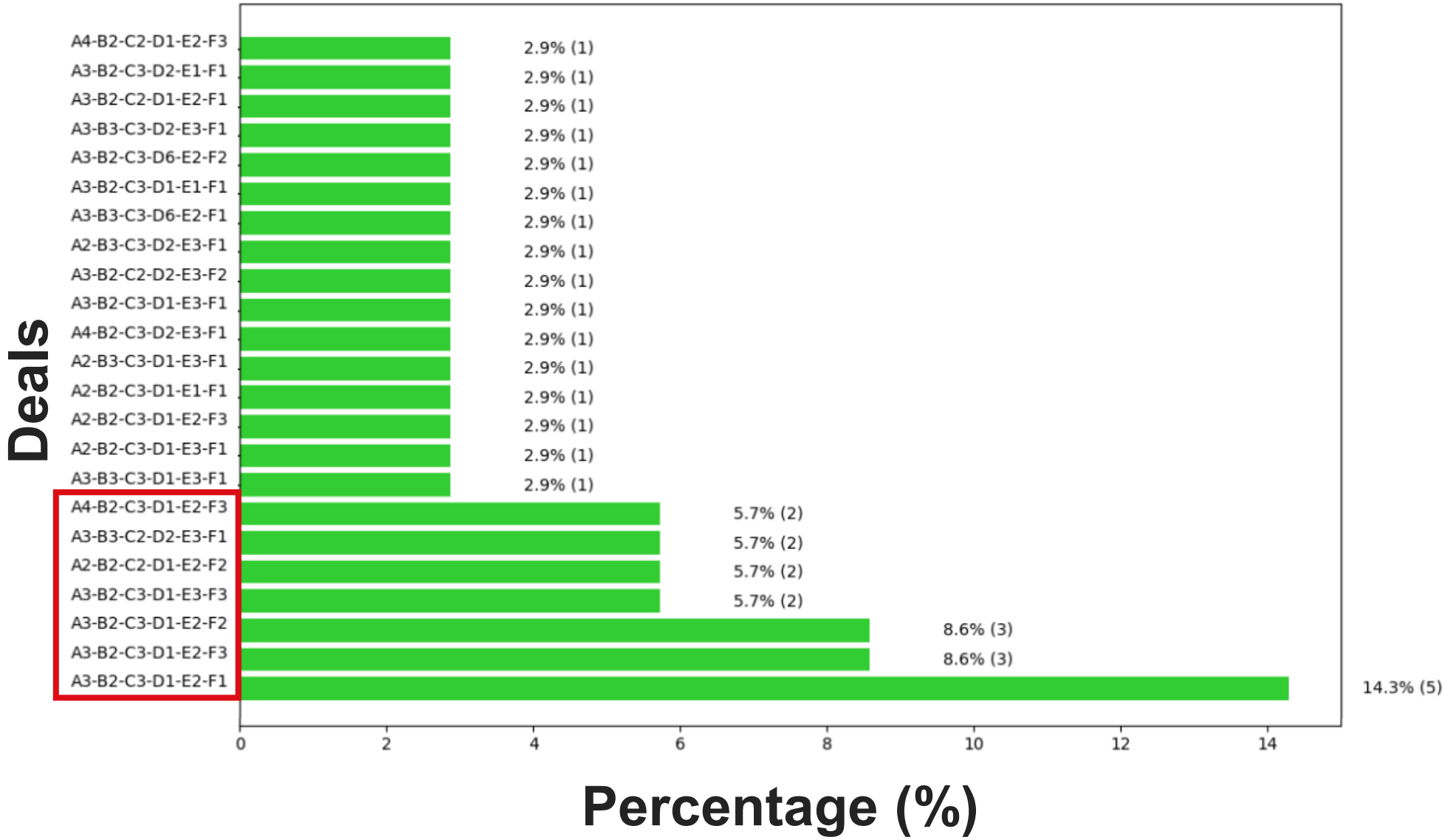
C2 is fair, but I would prefer B2 How about A2, B2,C2,…?

A2,B2 is acceptable, but only if I get C3

…

Deal: A3, B2, C2

Pipeline description: Main negotiations



Pipeline description: Main negotiations

Deal 3: Proposed by Forestry Services and Landowners

<SCRATCHPAD>
1) General Public and Community Groups have proposed: A4, B2, C2, D1, E2, F2. This suggests they value nature-based methods, targeted interventions, collaborative decision-making, and community engagement. They also emphasize ecological safeguards.

2) My preferences:
- A2 (17), A3 (17) are my top choices for Issue A. A4 is less preferred (5).
- B2 (17) aligns perfectly with my preference for Issue B.
- C3 (17) is my top choice for Issue C, but C2 (10) is acceptable.
- D1 (17) is my top choice for Issue D, and it aligns with the current proposal.
- E2 (17) aligns perfectly with my preference for Issue E.
- F1 (15), F2 (15), F3 (15) are all equally preferred for Issue F.

3) Current proposal score: A4 (5) + B2 (17) + C2 (10) + D1 (17) + E2 (17) + F2 (15) = 81

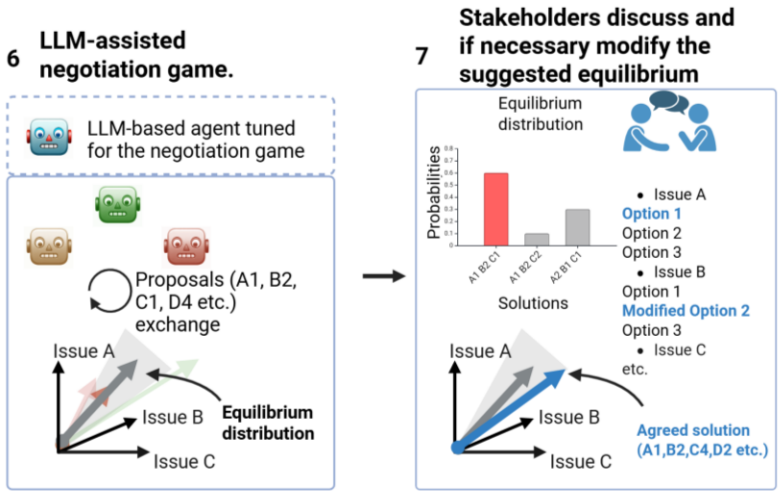
4) The current proposal meets my minimum score requirement and aligns well with my preferences, especially in Issues B, D, and E. I can accept this proposal as it stands, as it balances my interests with those of the General Public and Community Groups.

</SCRATCHPAD>

<ANSWER>
I support the current proposal as it aligns well with my interests and meets my minimum score requirement. <DEAL> A4, B2, C2, D1, E2, F2 </DEAL>
</ANSWER>

<PLAN>
In the next interaction, I can explore maintaining the current options for Issues B, D, and E, as they align well with my preferences. I should be open to discussing alternative options for Issues A, C, and F if needed to reach a consensus.
</PLAN>

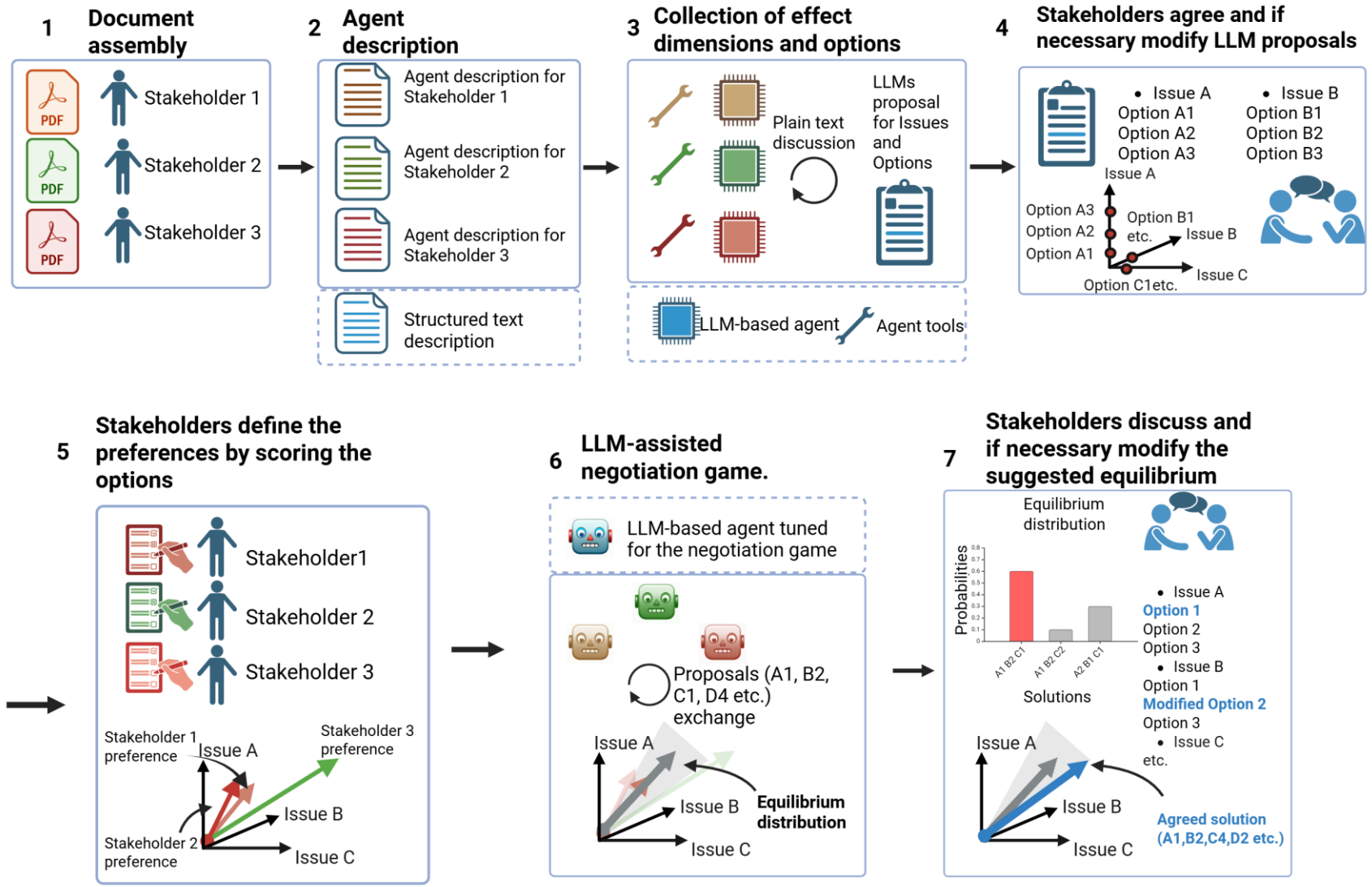
Pipeline description: Main negotiations



Q5 Were the proposed deals useful in achieving consensus on the problem to be negotiated between different stakeholders?

Answer Choices	Percentage	Responses
not useful at all	0%	0
not useful enough due to lack of significant aspects	0%	0
not useful enough due to large number of minor missing aspects	0%	0
useful enough despite lack of a high number of missing aspects	5.56%	1
useful enough despite minor missing aspects	38.89%	7
comprehensively useful and fit for purpose	55.56%	10

Pipeline description: complete pipeline



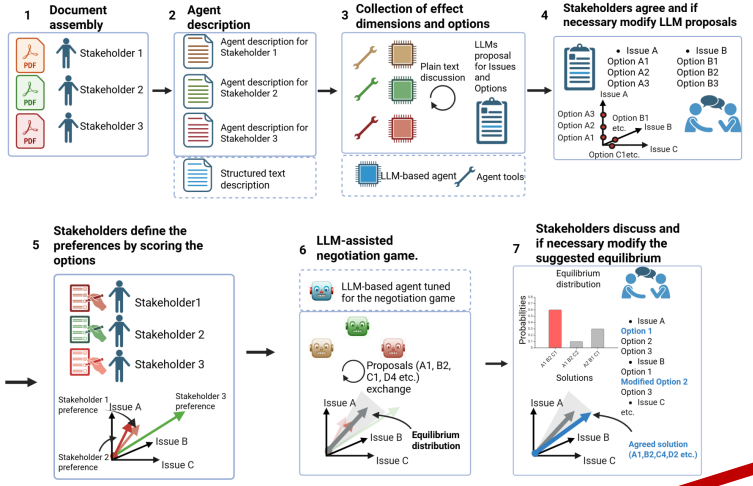
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Next steps and further development

Broad Topic:
How best to balance the trade-offs for setting a food safety microbiological criteria for Campylobacter spp in broiler meat according to the EU legislation No 2073/2005?

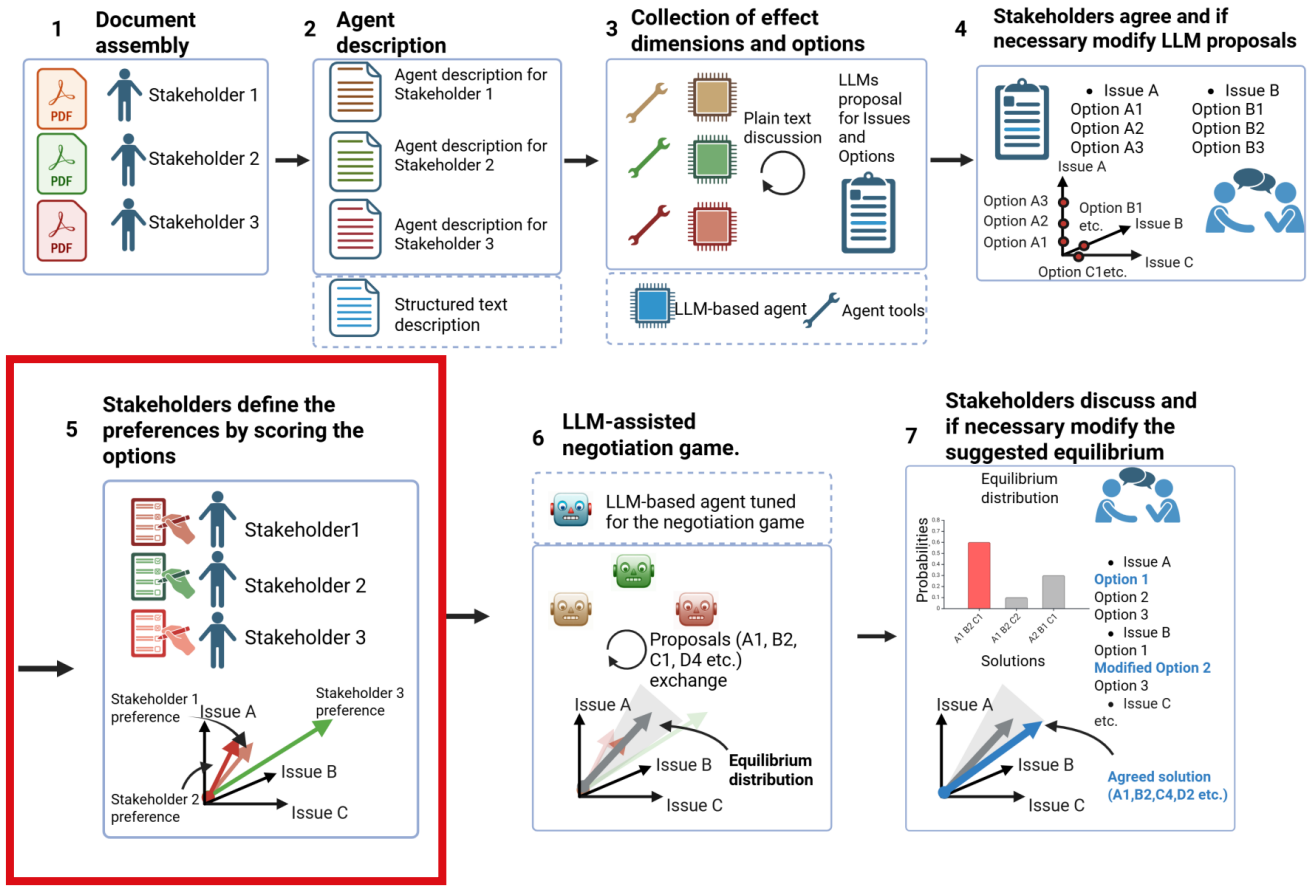


Concrete action proposal addressing various aspects of the problem based on the available data and simulated behaviour (e.g. A1, B2 etc.)

- Pipeline refinement. Integrating negotiation and game-theoretical approaches with probabilistic reasoning (e.g., Bayesian inference).

Next steps and further development

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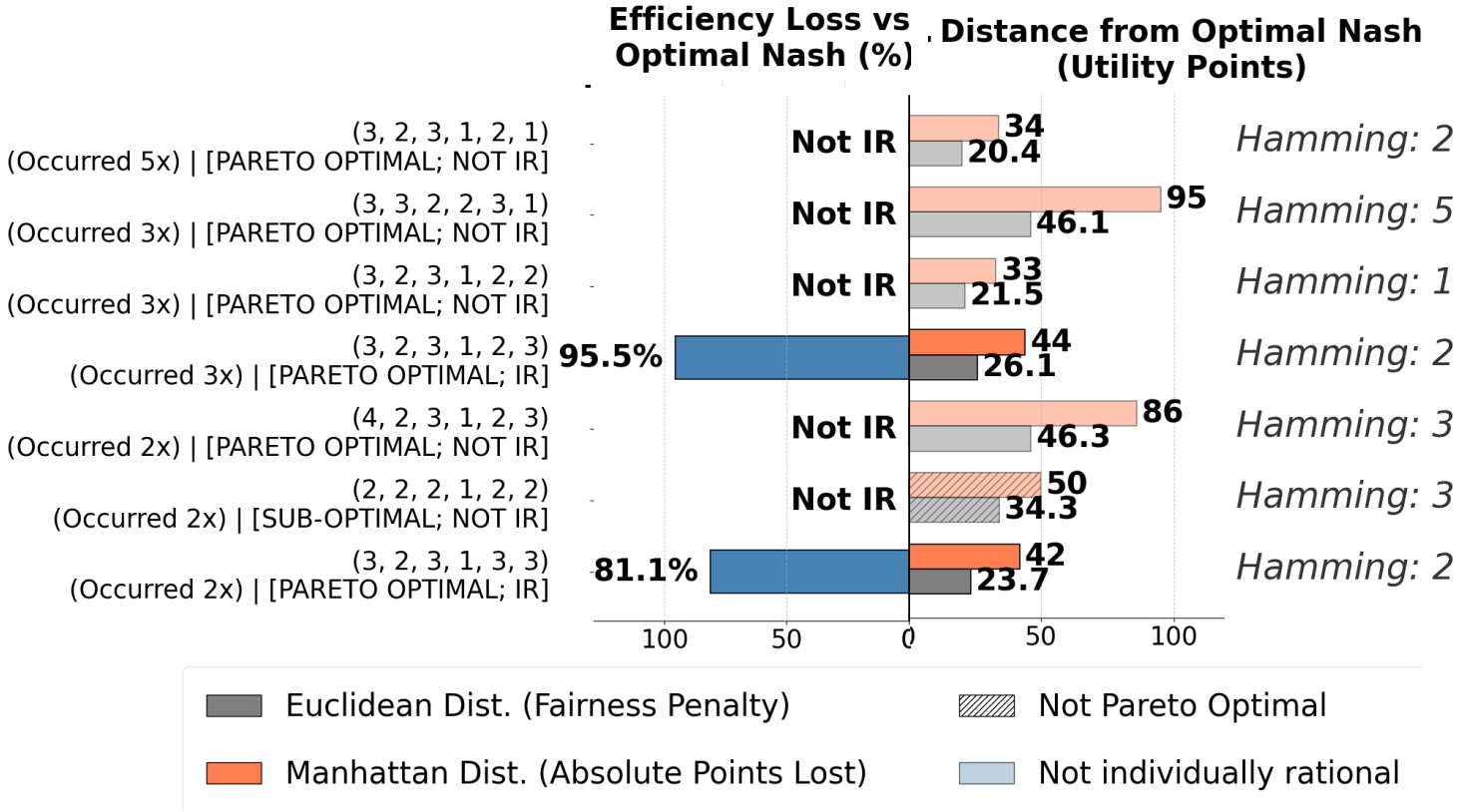
1. Individual Rationality – Acceptance
If the deal is acceptable for everyone (e.g. summed score is above the threshold)

2. Pareto Optimality - Efficiency
If you cannot make one party better without making at least one other party worse.

3. Nash Equilibrium – Balance
The most balanced joined gain over no deal

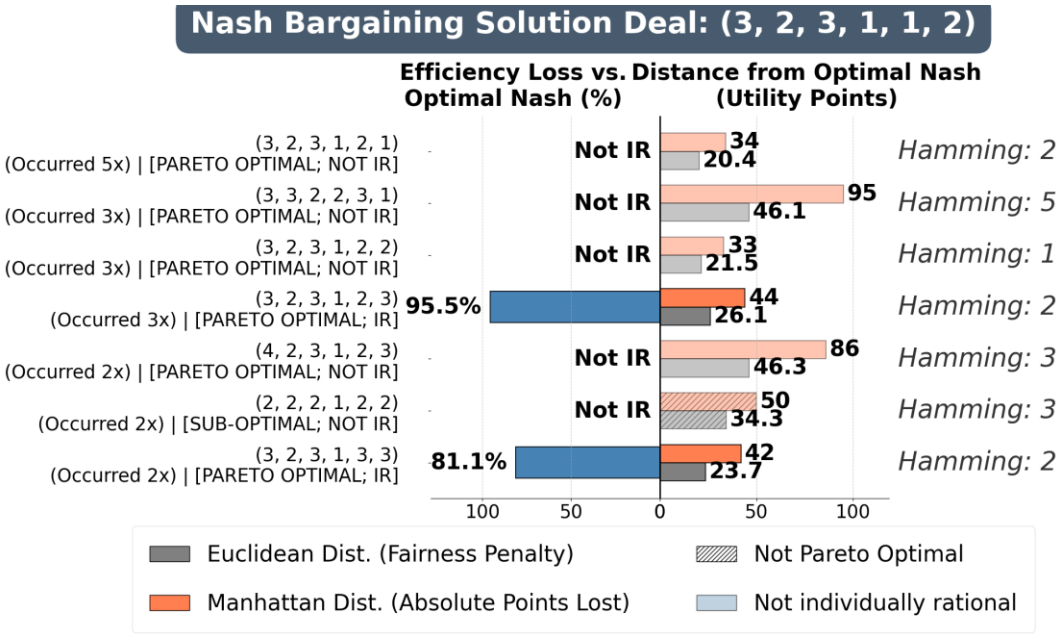
Next steps and further development

- Pipeline refinement. Integrating negotiation and game-theoretical approaches with probabilistic reasoning (e.g., Bayesian inference).



Next steps and further development

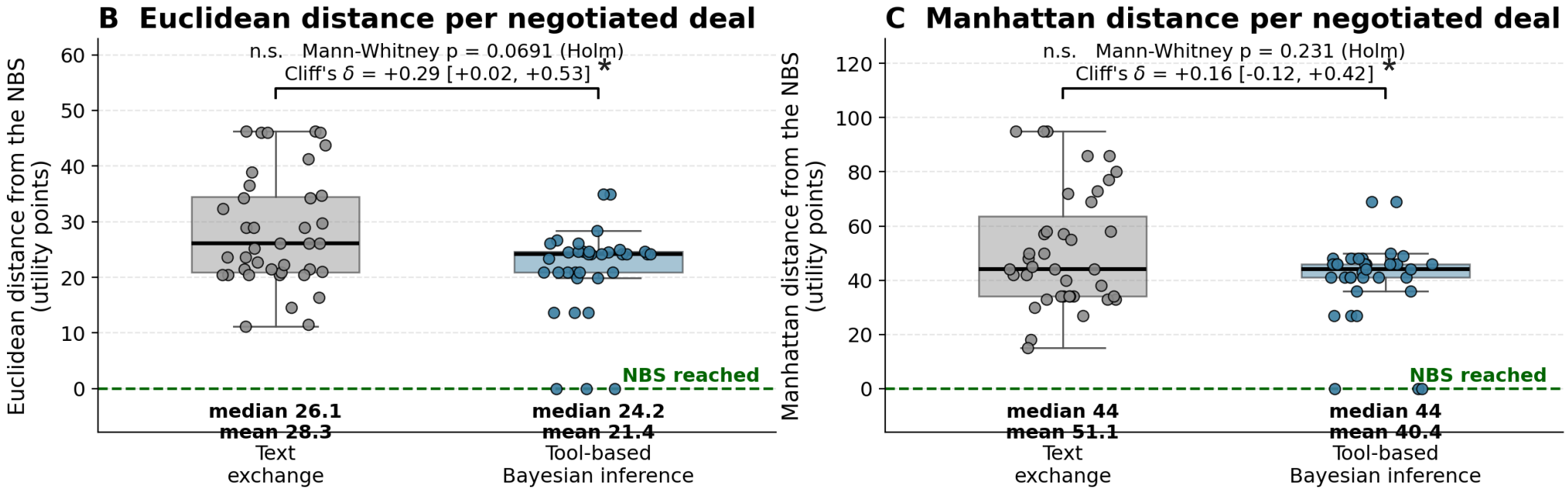
- Pipeline refinement. Integrating negotiation and game-theoretical approaches with probabilistic reasoning (e.g., Bayesian inference).



- Even though the most popular solutions were efficient (e.g. Pareto optimal), accepted by field stakeholders, they were not “mathematically balanced” (e.g. Nash equilibrium).

Next steps and further development

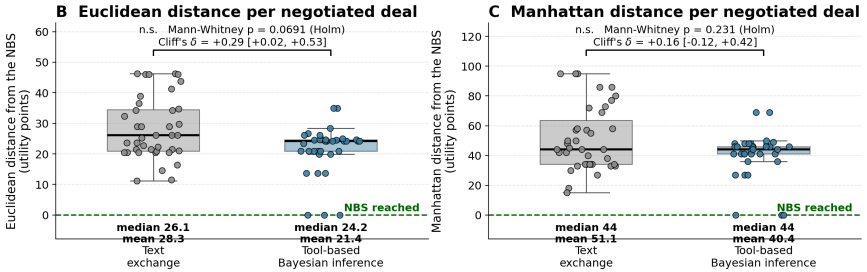
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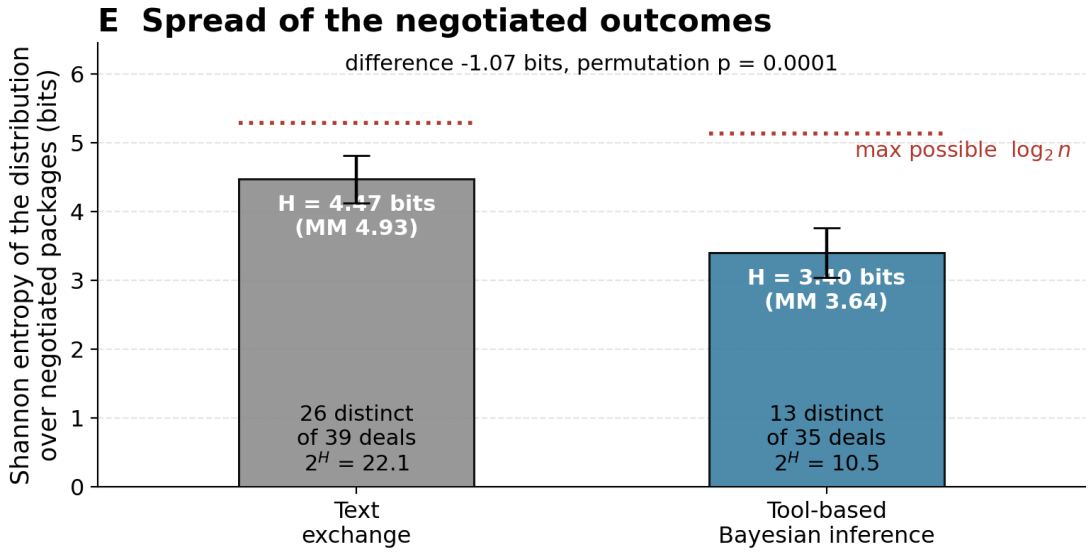


p: Mann-Whitney, Holm-adjusted across 3 metrics; δ: 95% bootstrap CI, unadjusted

Next steps and further development

- Pipeline refinement. Integrating negotiation and game-theoretical approaches with probabilistic reasoning (e.g., Bayesian inference).





✓ Integration of probabilistic reasoning tools allowed (i) reach a “fair” equilibrium and (ii) reduce noise and improve the deal reproducibility

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Want to be a part of the project?

Validation of the system on the new case scenarios





Acknowledgments










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MicRISK

ETH zürich

vetmeduni Mikrobiologie

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Thank you for your attention!