Reverse Chain: A Generic-Rule for LLMs to Master Multi-API Planning

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目录

项目背景：Tool-Augmented LLMs

- **动机**：LLMs 本身能力有限，不具备某些专业的功能（如计算器，天气预报等），因此能实现的任务也很有限。如果LLMs 具备使用工具的能力，将极大的拓展LLMs 处理任务的范围。
- **用法**：LLMs 作为 controllers:

1. 理解用户意图；2. 选择并使用正确的工具来完成任务。

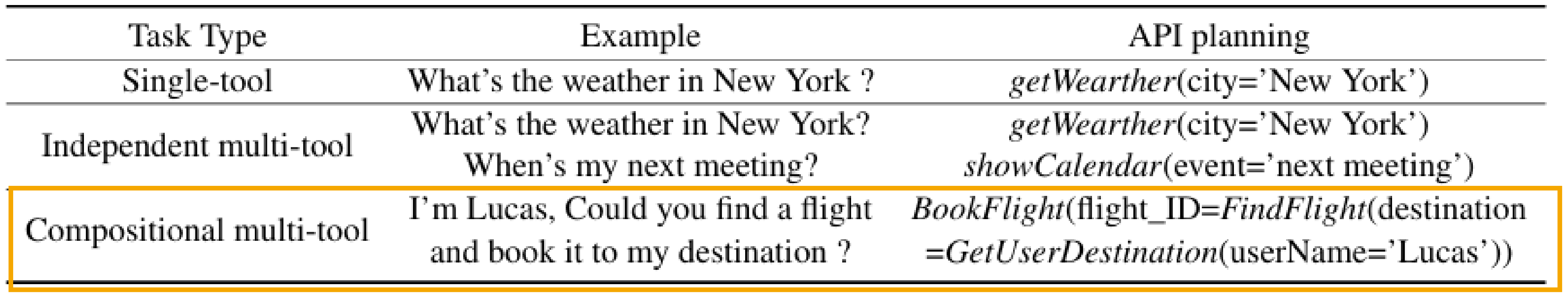
- **Example:**

QUERY: What’s the weather in New York ?

API PLANNING: getWearther (city=’New York’)

动机：任务的分类

有以下三种任务类型：相比于single-tool, multi-tool 任务更难，其中**compositional multi-tool**是最困难的，因为推理路径较长，且存在多层嵌套。



Task Type	Example	API planning
Single-tool	What’s the weather in New York ?	*getWearther*(city=’New York’)
Independent multi-tool	What’s the weather in New York? When’s my next meeting?	*getWearther*(city=’New York’) *showCalendar*(event=’next meeting’)
Compositional multi-tool	I’m Lucas, Could you find a flight and book it to my destination ?	*BookFlight*(flight_ID=*FindFlight*(destination =*GetUserDestination*(userName=’Lucas’))

Finetuned or In-context learning?
In-context learning 方案更直观更简单，而且更容易被泛化到新增API上。

动机：现存方法的缺陷

BookFlight(flight_ID = FindFlight (destination = GetUserDestination(username = ’Lucas’))

- Planning (One-step/CoT planning) [1,2,3]

优点：目标明确

缺点：计划之间未必可执行

BookFlight (flight_ID = FindFlight (destination=‘None’))

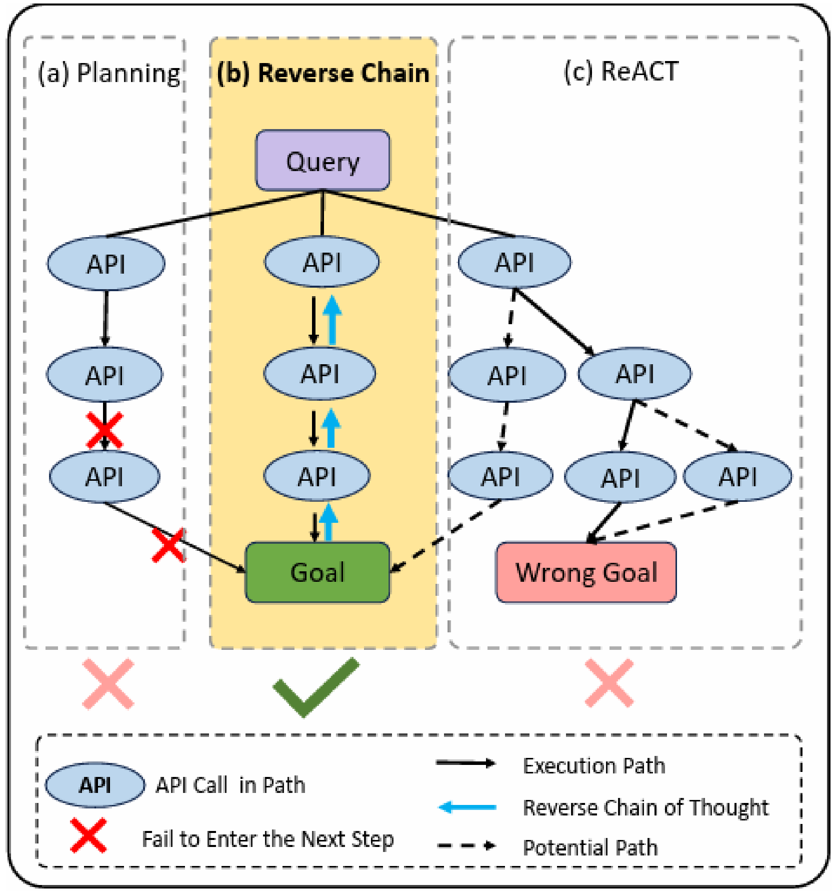
- ReAct [4,5,6]

优点：走一步看一步，因此每一步之间一定可执行

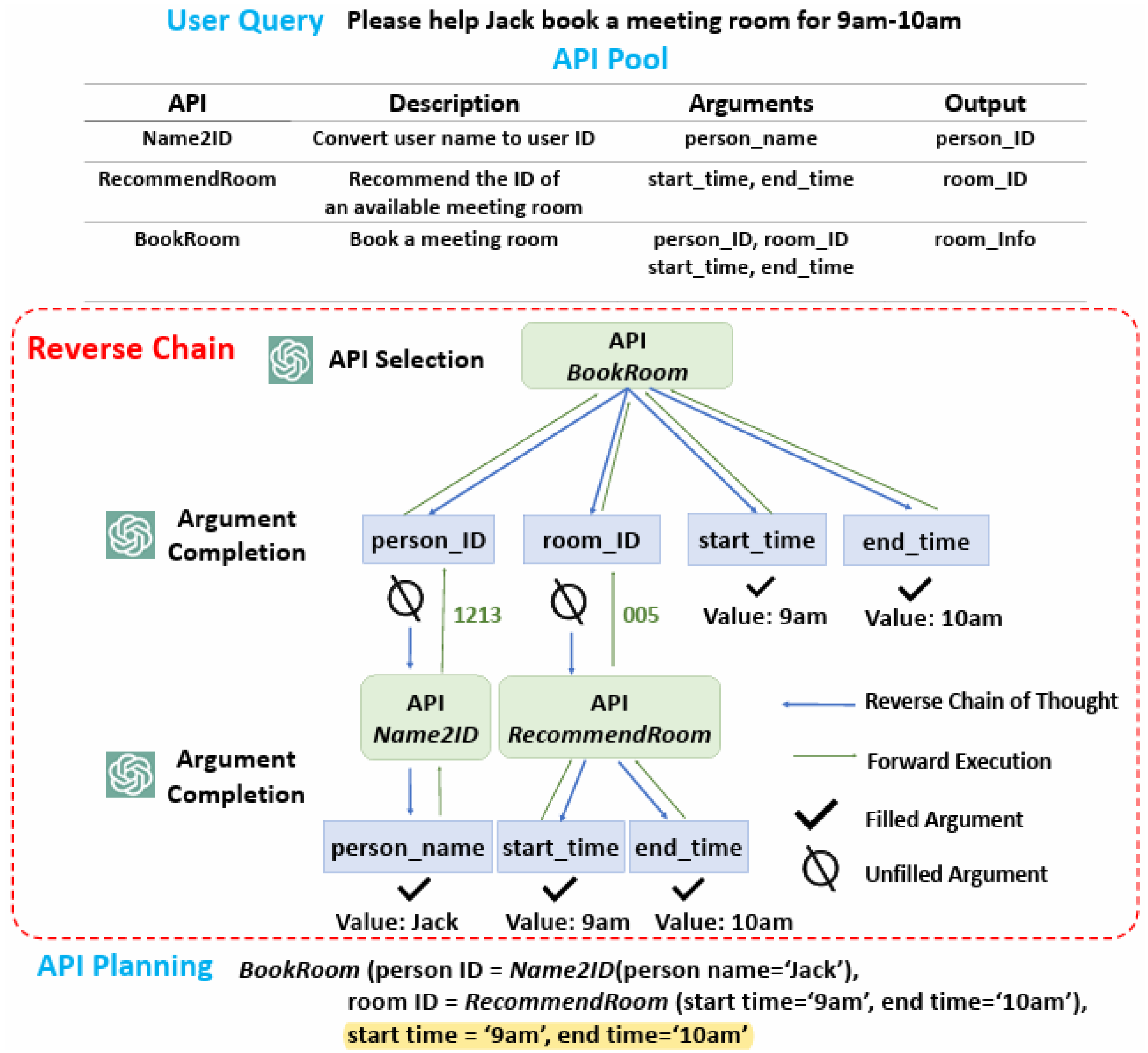
缺点：目标感较弱，容易走偏

GetUserDestination(userName=‘Lucas’)->destination,

flight_ID=FindFlight(destination)->FinalAnswer



方案: Reverse Chain



User Query Please help Jack book a meeting room for 9am-10am

API Pool

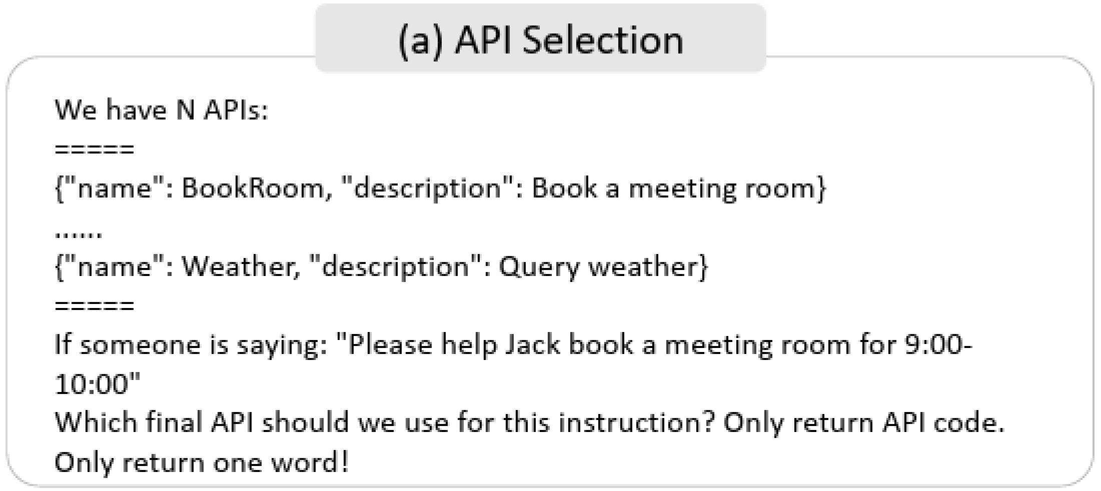
API	Description	Arguments	Output
Name2ID	Convert user name to user ID	person_name	person_ID
RecommendRoom	Recommend the ID of an available meeting room	start_time, end_time	room_ID
BookRoom	Book a meeting room	person_ID, room_ID start_time, end_time	room_Info

API Planning *BookRoom* (person ID = *Name2ID*(person name='Jack'),
room ID = *RecommendRoom* (start time='9am', end time='10am'),
start time = '9am', end time='10am'

- **Backward Reasoning**
从最终意图出发推理，保证了最终目标不发生偏移。

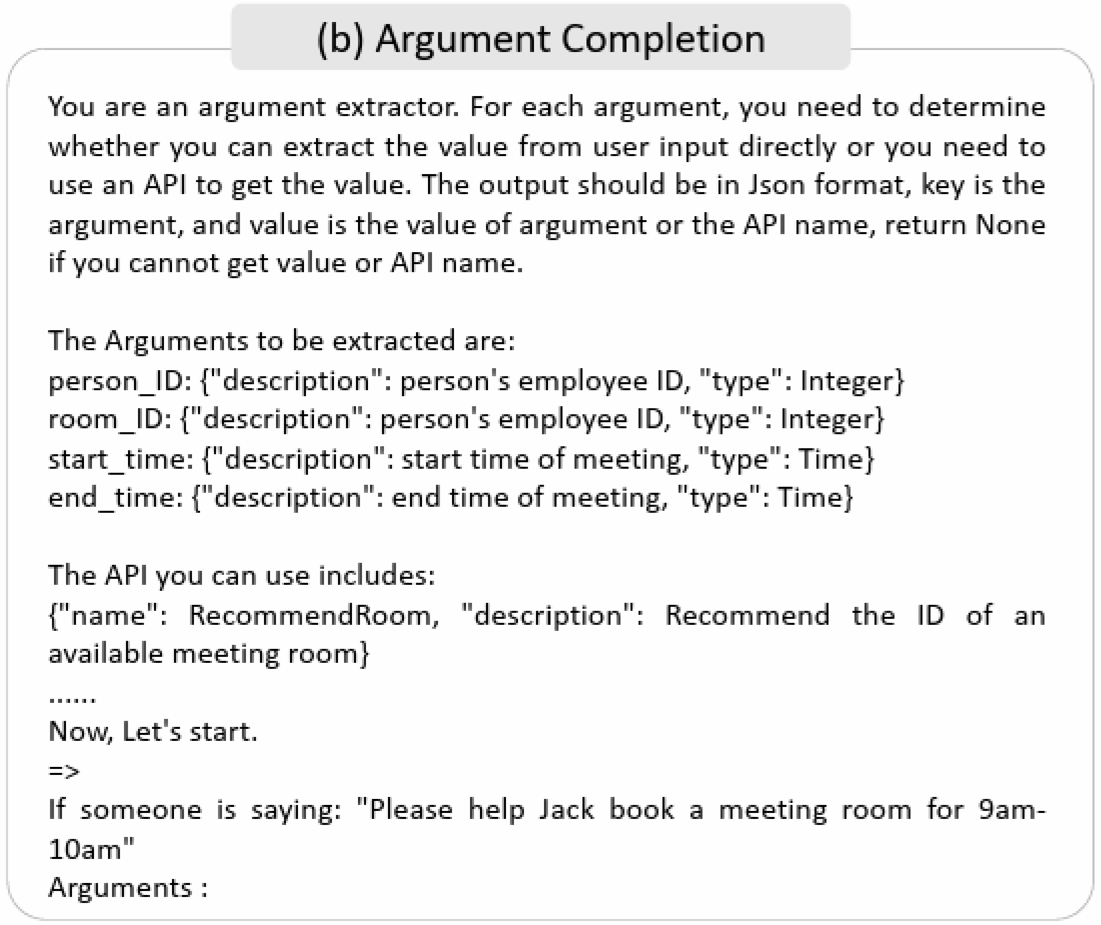
- **Generic rule + Decomposed task**
把复杂的API planning 任务拆分成两个处理自然语言的简单任务：API Selection + Argument Completion；且这个选择api+填写arguments 的链路能够保证每一个step之间都是可执行的。

方案：LLM Modules in Reverse Chain



(a) API Selection

We have N APIs:
=====
{"name": BookRoom, "description": Book a meeting room}
......
{"name": Weather, "description": Query weather}
=====
If someone is saying: "Please help Jack book a meeting room for 9:00-10:00"
Which final API should we use for this instruction? Only return API code. Only return one word!



(b) Argument Completion

You are an argument extractor. For each argument, you need to determine whether you can extract the value from user input directly or you need to use an API to get the value. The output should be in Json format, key is the argument, and value is the value of argument or the API name, return None if you cannot get value or API name.

The Arguments to be extracted are:
person_ID: {"description": person's employee ID, "type": Integer}
room_ID: {"description": person's employee ID, "type": Integer}
start_time: {"description": start time of meeting, "type": Time}
end_time: {"description": end time of meeting, "type": Time}

The API you can use includes:
{"name": RecommendRoom, "description": Recommend the ID of an available meeting room}
......
Now, Let's start.
=>
If someone is saying: "Please help Jack book a meeting room for 9am-10am"
Arguments :

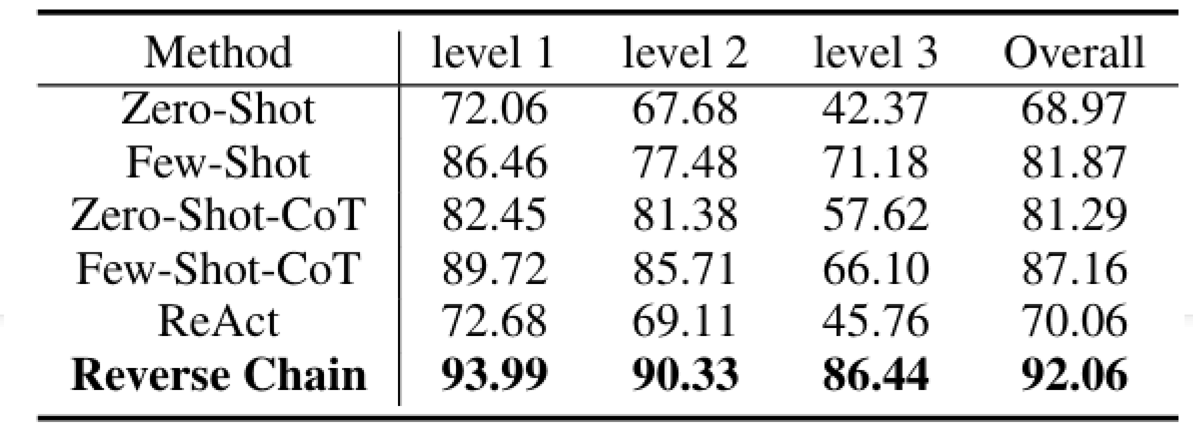
- **API selection**

LLM 根据PI的功能描述选择API

- **Argument Completion**

根据 argument的描述和数据类型，选择：
1. 直接从query中抽取value
2. 返回能够生成该argument value的API name
3. None, 触发反问机制

实验效果



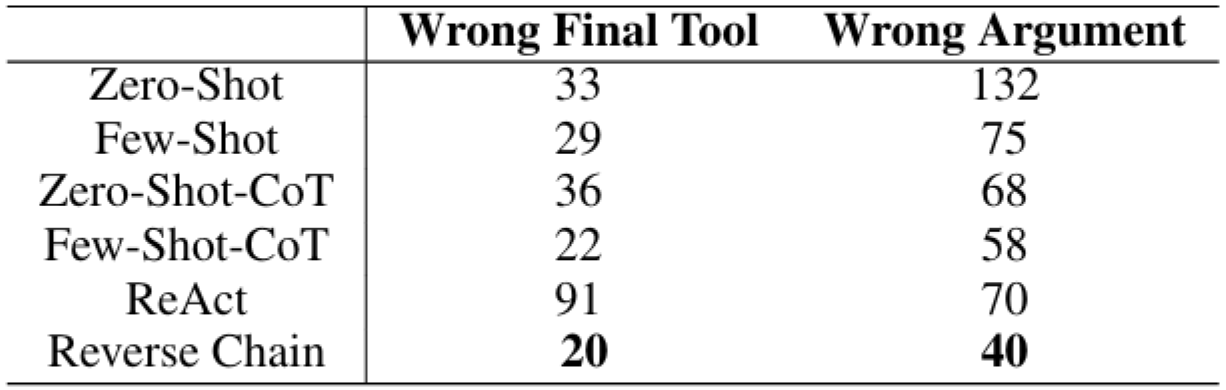
Method	level 1	level 2	level 3	Overall
Zero-Shot	72.06	67.68	42.37	68.97
Few-Shot	86.46	77.48	71.18	81.87
Zero-Shot-CoT	82.45	81.38	57.62	81.29
Few-Shot-CoT	89.72	85.71	66.10	87.16
ReAct	72.68	69.11	45.76	70.06
Reverse Chain	**93.99**	**90.33**	**86.44**	**92.06**

- **Experiment setting:**
  - **Dataset:**
  通过GPT-4和ChatGPT自动构造+人工过滤;
  包含涉及20个不同领域的825个不同的API，共1550条样本;
  样本包含2,3,4,5 层的嵌套。平均每个样本包含2.93个 function calls。
  - **Metrics:**
  主要评测API的选择， API 参数值，API 之间的调用关系是否正确;
  针对不同baseline methods 的设计不同的GPT-4.0 自动评测方案，抽样得到89%的人工一致性。

- **Results:**
  以ChatGPT作为基座LLM，Reverse chain 相比于其他方法都有显著的提升，并且在嵌套层数多的时候提升更加明显。

Why Reverse chain works?

把错误分成两大类：**Wrong final tool** 和 **Wrong argument**
可以看到reverse chain能有效降低这两种错误。



	Wrong Final Tool	Wrong Argument
Zero-Shot	33	132
Few-Shot	29	75
Zero-Shot-CoT	36	68
Few-Shot-CoT	22	58
ReAct	91	70
Reverse Chain	**20**	**40**

Table 6: Error cause statistics all methods.

参考文献

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[2] Taskmatrix.ai: Completing tasks by connecting foundation models with millions of apis.

[3] Chain-of-thought prompting elicits reasoning in large language models.

[4] React: Synergizing reasoning and acting in language models.

[5] Rest-gpt: Connecting large language models with real-world applications via restful apis.

[6] Tptu: Task planning and tool usage of large language model-based ai agents.