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OpenSPG-KAG

KAG: 知识增强生成的垂域知识库知识服务框架

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基础智能-语言与机器智能部-知识引擎

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大模型垂域应用(RAG+LLM)关键问题

LLM 垂域应用一般配备私域知识库，以解决:

- 垂域隐私数据难以成为 开源&商业 大模型预训练语料
- 大模型 sft 对人员能力&资源配置 要求较高
- 大模型 sft 耗时长，难以与知识库更新保持同步

RAG+LLM 模式落地遇到的挑战

垂域知识（结构化&非结构化&专家规则）如何统一管理?

知识统一管理

文本&向量的存储结构，无法提供新闻、事件、日志、书籍等非结构化数据，交易、统计、审批等结构化数据，业务经验、领域知识等专家规则 的统一管理

符号推理表达&执行（三国演义有多少出身荆州的武将）

符号推理

基于分词&语义相似的召回策略，无法胜任复杂推理、量化分析、运筹优化、精细化匹配等决策任务

知识库数据质量（歧义、稀疏等）如何提升

知识库质量

垂域知识库存在较多歧义，诸如Apple、小米等同名不同义，诸葛亮、武乡侯、孔明先生等同义不同名 的问题

动态数据与领域静态概念树的脱节问题

知识图谱所倡导技术路线（语义、逻辑、符号等）可为大模型垂域应用提供更好支持

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图谱/图+大模型 典型技术路线

框架	适用场景	特点
GraphRAG(MS)	摘要生成类任务(评估方式:可理解性、完整性、多视角)	• 通过层次聚类实现段落摘要的逐级生成，更关注答案生成的可理解性、完整性、多视角 • 多跳问答等评测集量化指标较差，未提供逻辑符号推理的能力
HippoRAG	事实问答类任务(评估方式:em、f1)	• 通过rdf 抽取 + 语义相似拉边，完成图谱构建 • 问答阶段，通过dpr + ppr 实现Chunk 召回 • 未利用语义、逻辑、符号等图谱技术栈
LightRAG	摘要生成类任务(评估方式:可理解性、完整性、多视角)	• 通过rdf 五元组（带类型）抽取完成图谱构建 • 问答阶段，通过对query 中所包含实体、实体归属的概念实现Chunk 召回 • 未利用语义、逻辑、符号等图谱技术栈
OpenSPG-KAG (V0.5)	事实问答类任务+逻辑推理类任务(评估方式:em、f1)	• 基于知识抽取、语义对齐、文本&图互索引等完成图谱知识库构建 • 基于逻辑符号引导的混合推理, 实现事实问答&逻辑推理类任务。 • 摘要生成、对话问答类任务，待开源… • kag-model 小模型媲美大模型效果，待开源…

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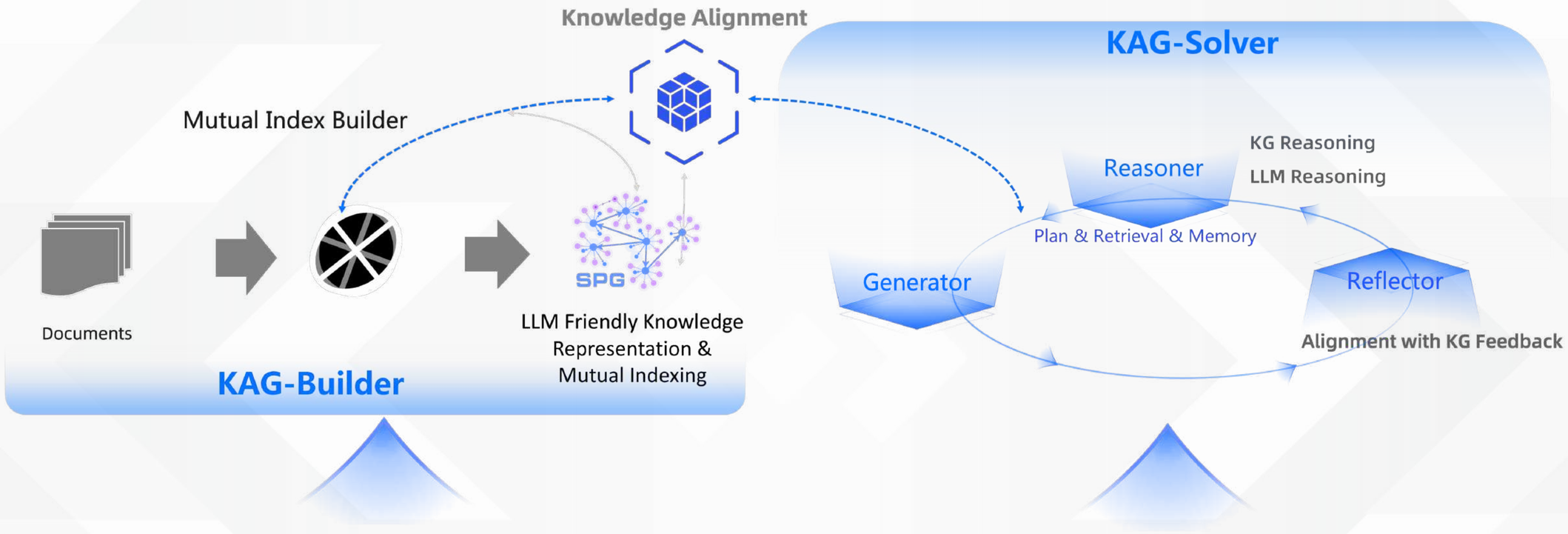
KAG 介绍

V0.5 版本

KAG - 技术架构

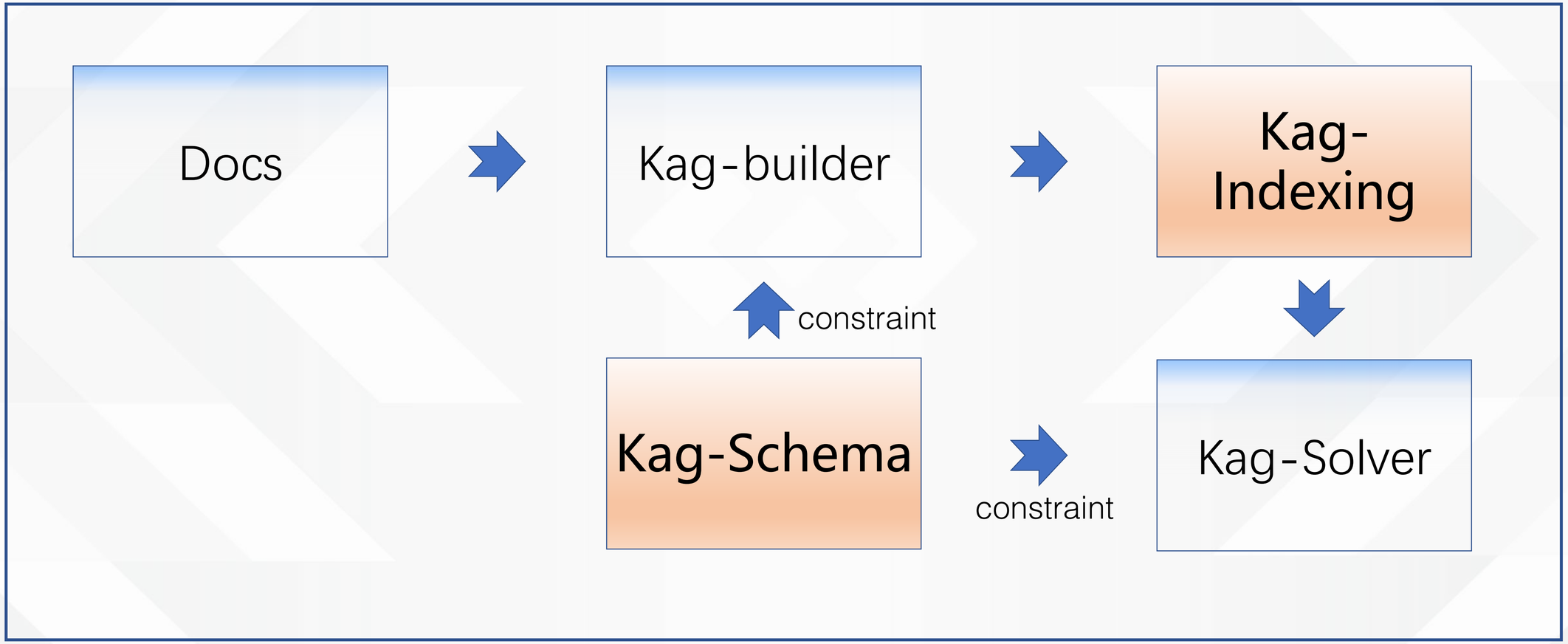


Kag-builder: 大模型友好的知识表示

Kag-solver: 逻辑符号引导的混合推理引擎

Kag-Model: 10B sft 模型媲美 72B 模型效果(NLU, NLI, NLG 任务)，资源消耗显著降低

KAG-Schema & Indexing



Kag-Schema(升级SPG为面向大模型友好)

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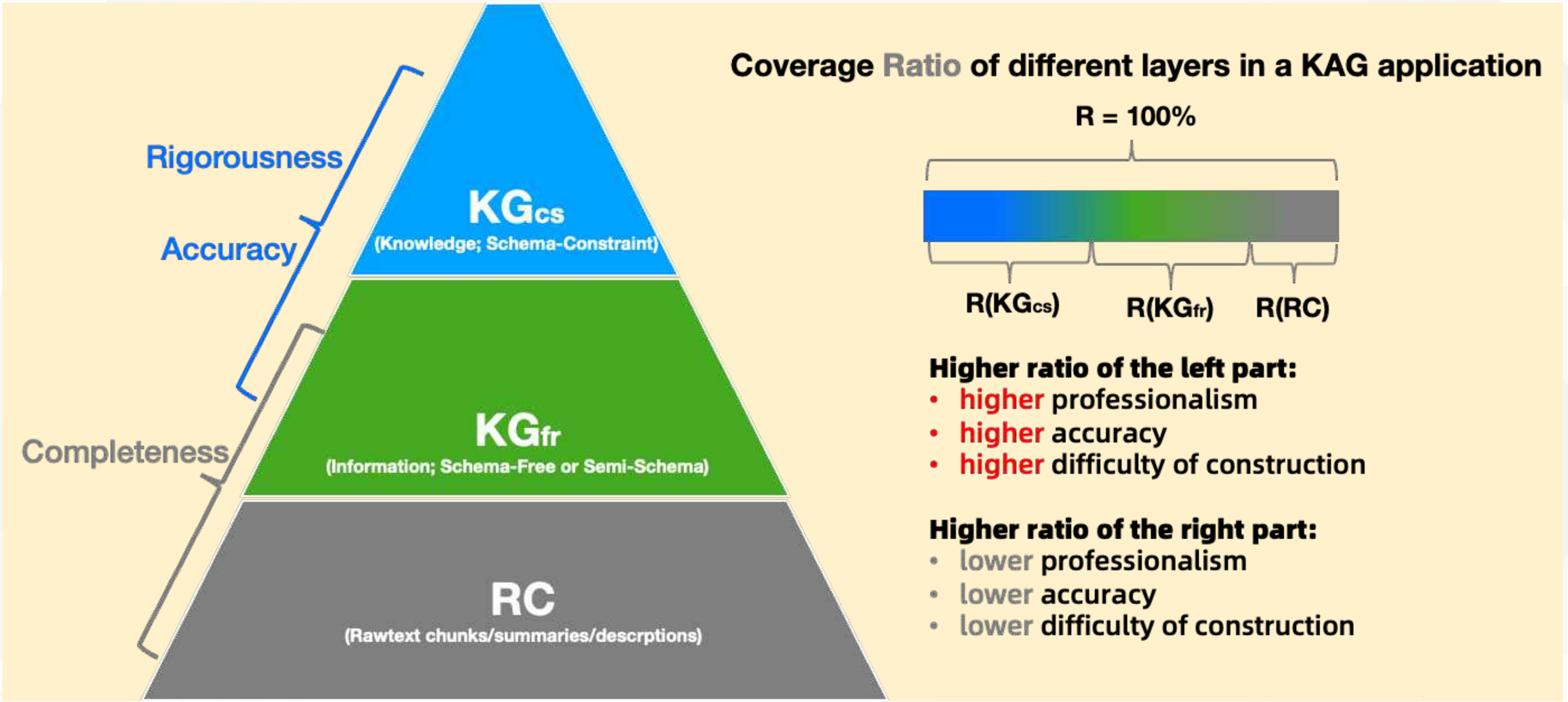
medicine.schema(医疗)

```
namespace Medical

Disease(疾病): EntityType
    properties:
      desc(描述): Text
        index: Text
      semanticType(语义类型): Text
        index: Text
      complication(并发症): Disease
        constraint: MultiValue
      commonSymptom(常见症状): Symptom
        constraint: MultiValue
      applicableMedicine(适用药品): Medicine
        constraint: MultiValue
      diseaseSite(发病部位): HumanBodyPart
        constraint: MultiValue

HospitalDepartment(科室): ConceptType
    hypernymPredicate: isA

HumanBodyPart(人体部位): ConceptType
    hypernymPredicate: isA

HypertensionLevel(高血压分级): ConceptType

SCAD(稳定性冠心病): ConceptType

Drug(药品): ConceptType
……
```

Hypertension.rule（高血压诊断&用药规则）

```
namespace Medical

(HypertensionLevel/`高血压`):
    rule: [[
        收缩压>=140 or 舒张压>=90
    ]]

[联合用药方案]->(Drug/`ACEI`+`β受体阻滞剂`):
    rule:[[
        ()-[:conclude]->(:Medical.SCAD) and (()-[:适用药品]->(:Medical.Drug/`β受体阻滞剂`) or ()-[:推荐药品]->(:Medical.Drug/`β受体阻滞剂`)) and (()-[:适用药品]->(:Medical.Drug/`ACEI`) or ()-[:推荐药品]->(:Medical.Drug/`ACEI`))
    ]]

[适用药品]->(Drug/`β受体阻滞剂`):
    rule:[[
        ()-[:conclude]->(:Medical.SCAD) and HypertensionLevel/`高血压`
    ]]

[推荐药品]->(Drug/`β受体阻滞剂`):
    rule:[[
        HypertensionLevel/`高血压` and ()-[:conclude]->(:Medical.SCAD) and 心率 > 60
    ]]
```

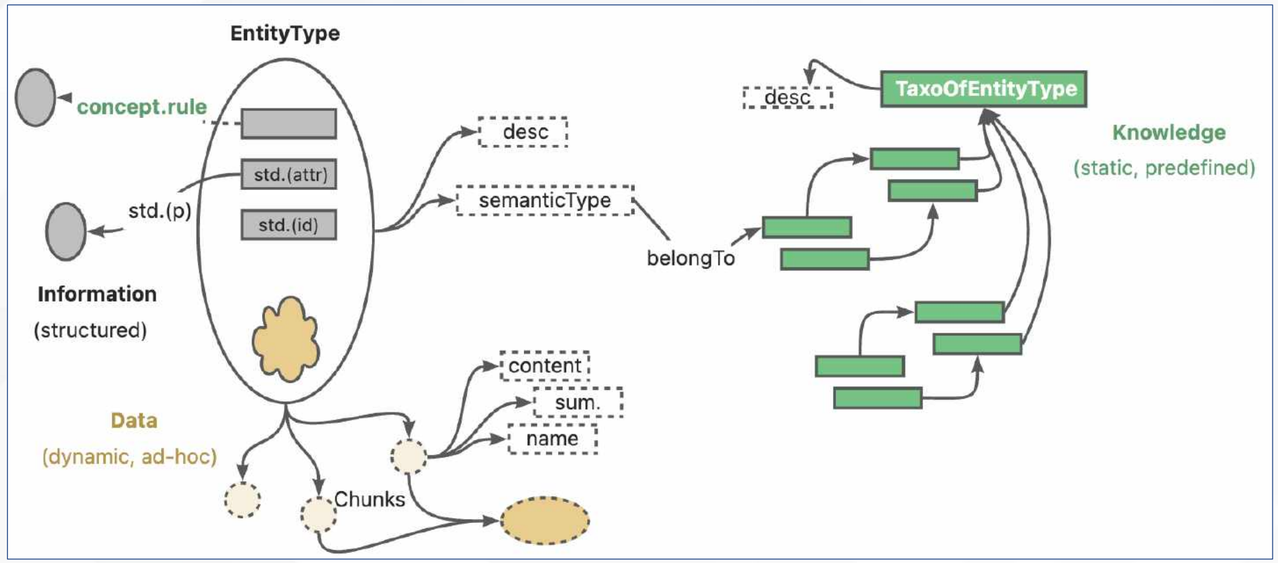
Kag-Indexing知识分层



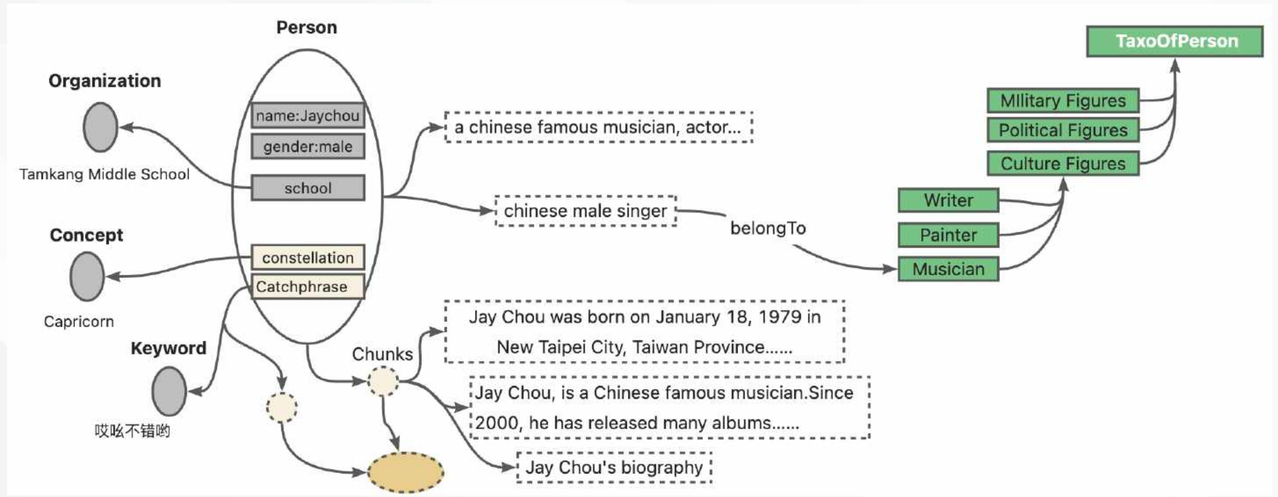
- 升级SPG为面向大模型友好的知识表示LLMFriSPG
- 兼容强Schema**专业知识**和弱Schema**开放信息**
- 图结构知识与文本知识的**互索引结构**
- 专业领域可平滑调节的**专业决策**与**信息检索，丰富知识完备性**

LLMFriSPG示例

Kag – Indexing Structure



Kag – Indexing instance of Jay Chou



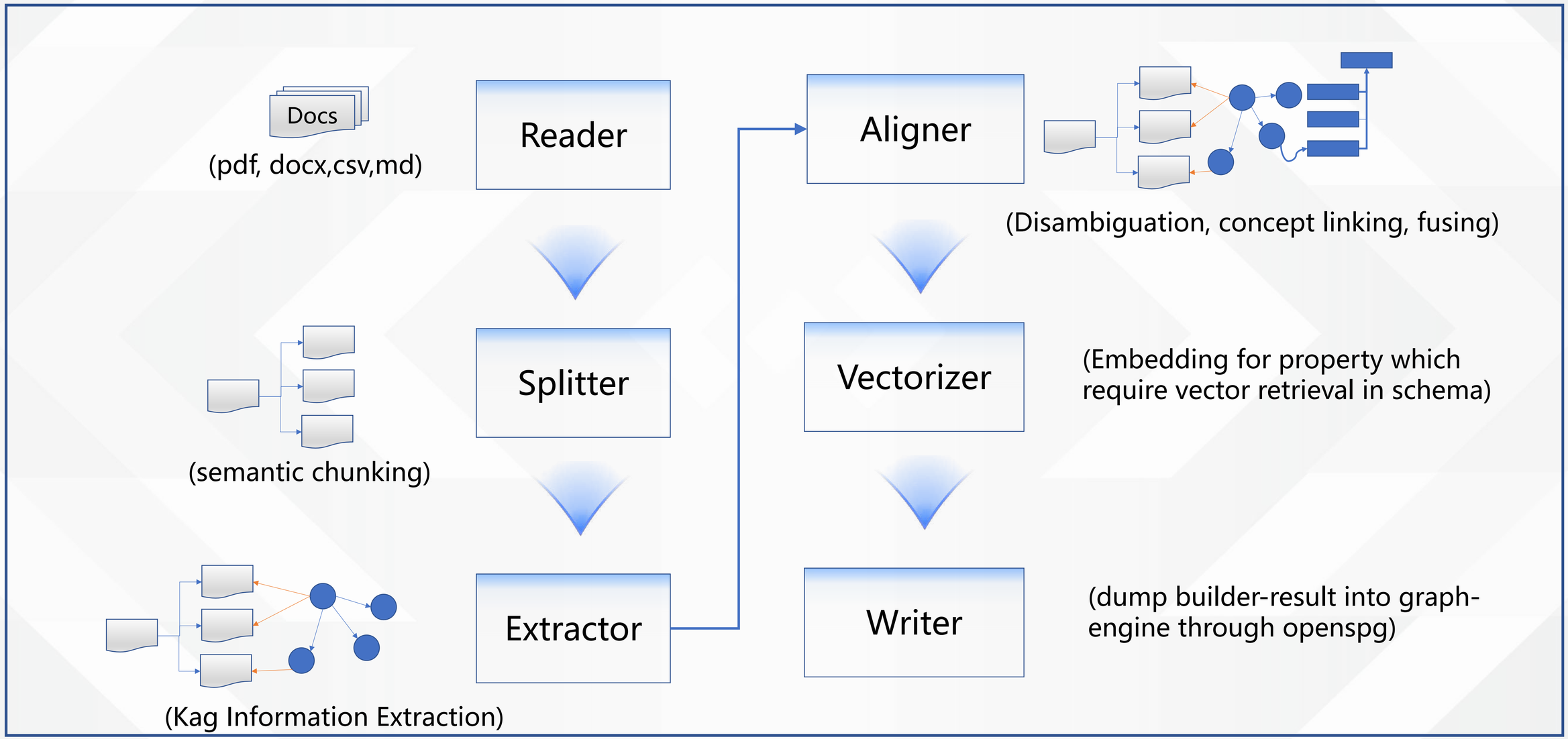
default.schema

Organization(组织机构): EntityType
  properties:
    id(主键): Text
      index: TextAndVector
    name(机构名): Text
      index: TextAndVector
    desc(描述): Text
      index: TextAndVector
    semanticType(语义类型): Text

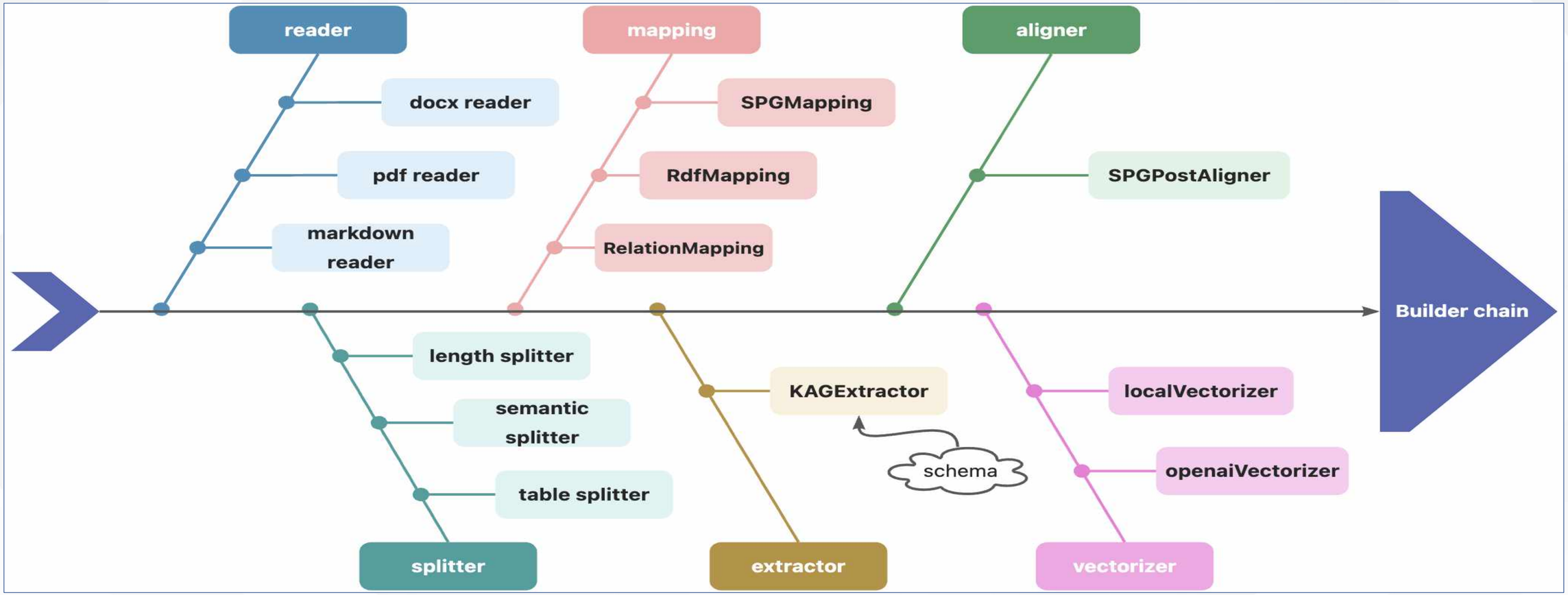
Person(人物): EntityType
  properties:
    id(主键): Text
      index: TextAndVector
    name(姓名): Text
      index: TextAndVector
    desc(描述): Text
      index: TextAndVector
    school (毕业院校): Organization
    gender (性别): Text
    semanticType(语义类型): Text

Works(作品): EntityType
Concept(概念): EntityType
GeoLocation(地理位置): EntityType
……
Chunks(文章段落): EntityType
Others(其它): EntityType

Kag-builder


Docs
(pdf, docx,csv,md)
Reader
Splitter
(semantic chunking)
Extractor
(Kag Information Extraction)
Aligner
(Disambiguation, concept linking, fusing)
Vectorizer
(Embedding for property which require vector retrieval in schema)
Writer
(dump builder-result into graph-engine through openspg)

Kag-builder（built-in components）



- Kag 内置了reader, splitter, mapping, extractor, aligner, vectorizer 的多种实现
- Kag-builder chain 前一个节点的输出格式与后一个节点的输入格式对齐
- Schema（默认、自定义） 引导大模型完成图谱知识抽取&语义对齐
- Kag-builder 生成的subgraph 子图，调用openspg-writer接口写入图存引擎

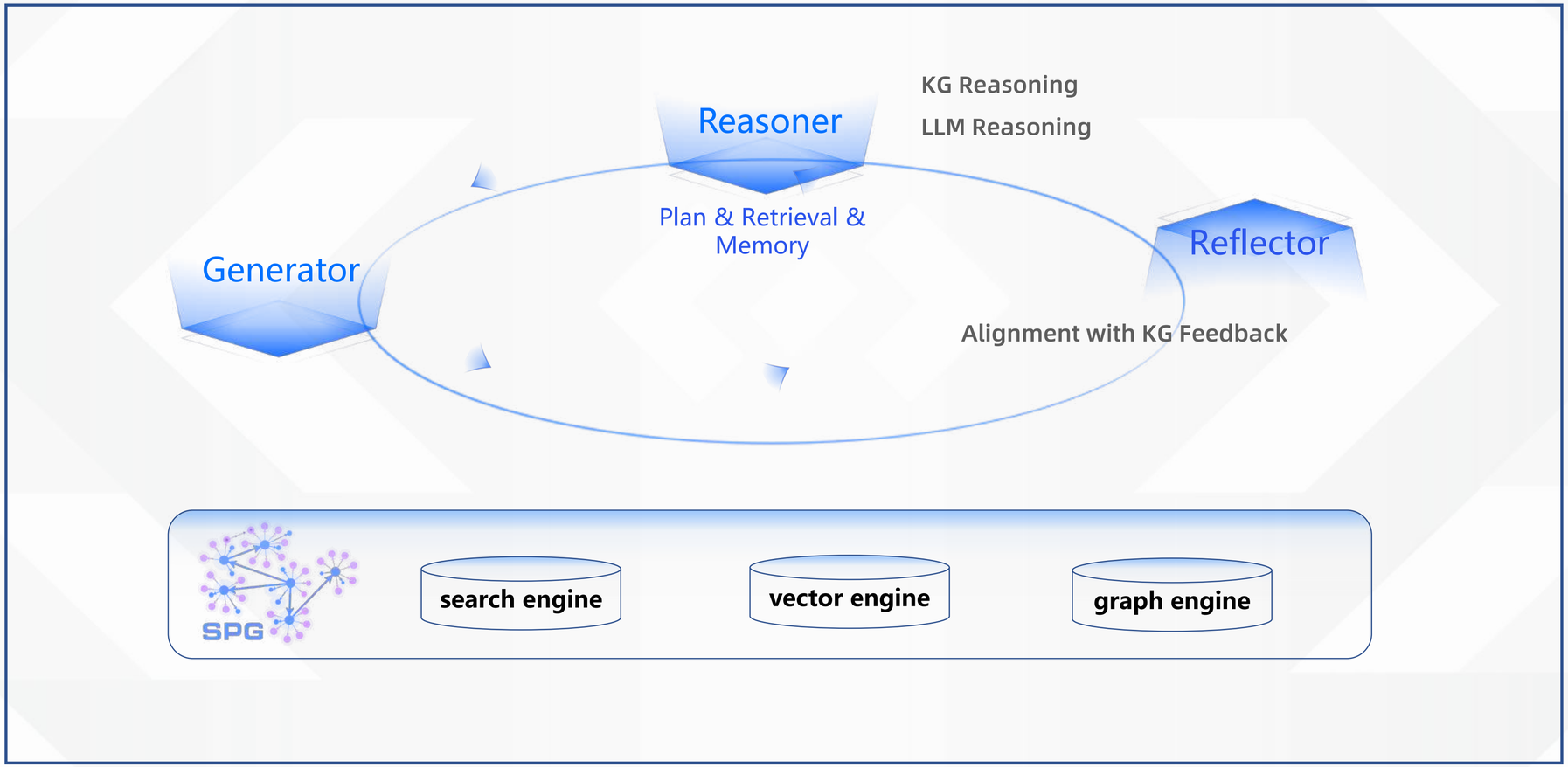
Kag-builder（Interface & example）

```
kag
├──interface
│   ├── builder
│   │   ├── aligner_abc.py
│   │   ├── extractor_abc.py
│   │   ├── mapping_abc.py
│   │   ├── reader_abc.py
│   │   ├── splitter_abc.py
│   │   ├── vectorizer_abc.py
│   │   └── writer_abc.py
```

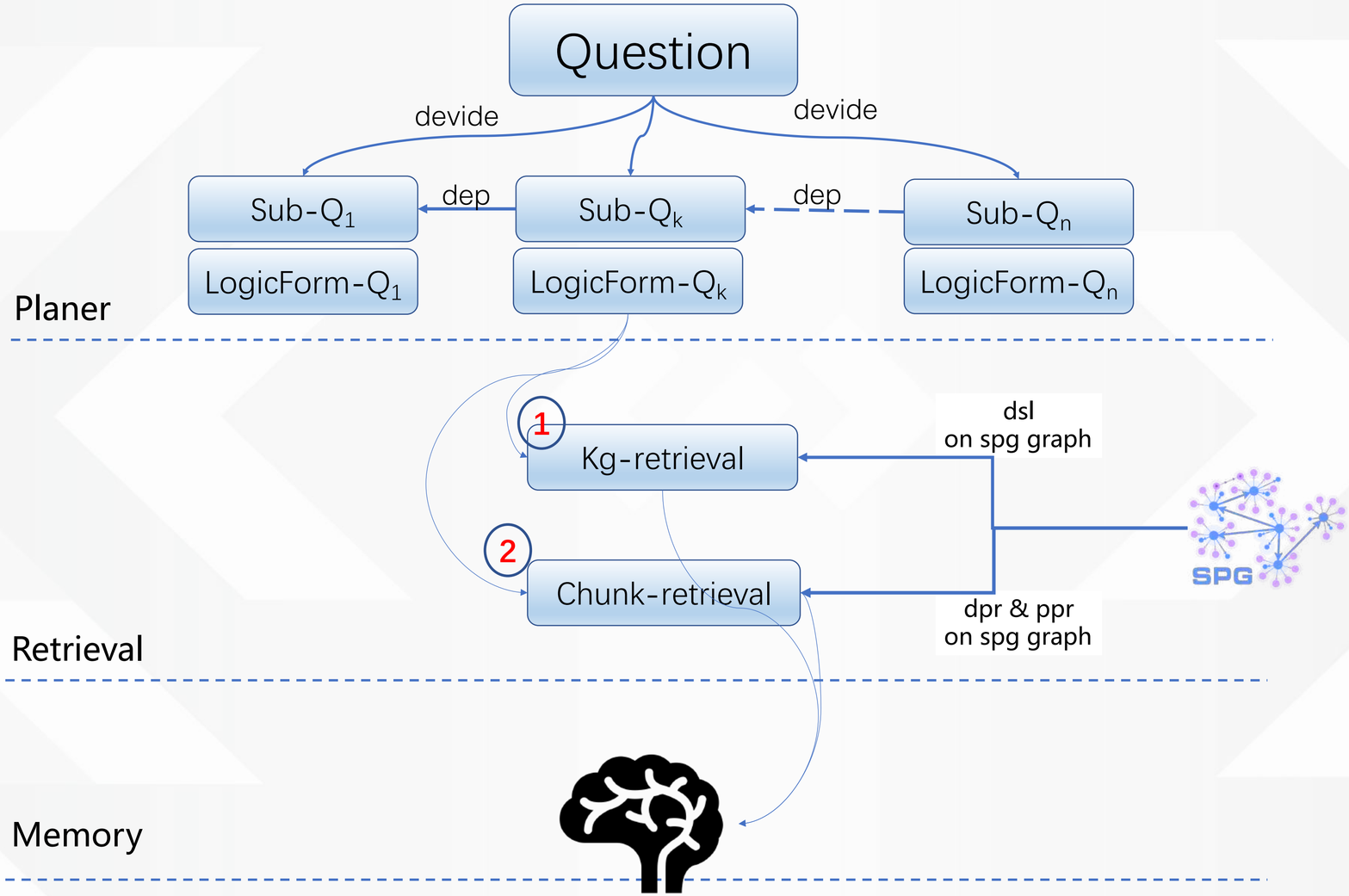
```python
class SourceReaderABC(BuilderComponent, ABC):  庄舟
    """
    Interface for reading files into a list of unstructured chunks or structured dicts.
    """

    @property  庄舟
    def input_types(self) -> Input:
        return str

    @property  庄舟
    def output_types(self) -> Output:
        return Union[Chunk, Dict]

    @abstractmethod  庄舟
    def invoke(self, input: Input, **kwargs) -> List[Output]:
        raise NotImplementedError(
            f"`invoke` is not currently supported for {self.__class__.__name__}."
        )
```

```python
class DiseaseBuilderChain(BuilderChainABC):
    def build(self, **kwargs):
        source = CSVReader()
        splitter = LengthSplitter()
        extractor = KAGExtractor()
        vectorizer = BatchVectorizer()
        sink = KGWriter()
        return (source >> splitter >> extractor
                >> vectorizer >> sink)

if __name__ == '__main__':
    # default chain for structureed data
    DefaultStructuredBuilderChain().invoke("data/xx.csv")
    # customized chain for unstructured data
    DiseaseBuilderChain().invoke("data/Disease.csv")
```

KAG-Solver


KG Reasoning
LLM Reasoning
Reasoner
Plan & Retrieval &
Memory
Generator
Reflector
Alignment with KG Feedback
SPG
search engine
vector engine
graph engine

Kag-Solver（reasoner）



Kag-Solver（自定义扩展）

Kag-solver interface

```
kag
├── solver
│   ├── logic
│   │   └── solver_pipeline.py
├── interface
│   ├── retriever
│   │   ├── chunk_retriever_abc.py
│   │   └── kg_retriever_abc.py
│   ├── solver
│   │   ├── kag_generator_abc.py
│   │   ├── kag_memory_abc.py
│   │   ├── kag_reasoner_abc.py
│   │   ├── kag_reflector_abc.py
│   │   └── lf_planner_abc.py
```

Kag-solver prompt

```
prompt
├── default
│   ├── deduce_choice.py
│   ├── deduce_judge.py
│   ├── logic_form_plan.py
│   ├── resp_extractor.py
│   ├── resp_generator.py
│   ├── resp_judge.py
│   ├── resp_reflector.py
│   ├── resp_verifier.py
│   └── solve_question.py
├── lawbench
│   └── logic_form_plan.py
```

LogicForm Plan interface

```
class LFPlannerABC(KagBaseModule, ABC):
    """
        LFPlanResult is a LogicForm expression.
        kag provides Retrieval(kg-retrieval、chunk-retrieval) function for LogicF
orm execution
        kag provides Deduce (judgement|entailment|rule|choice|multiChoice) functi
on for LogicForm execution
        kag provides Output(refer output of former function) function for LogicFo
rm execution
    """
    @abstractmethod
    def lf_planing(self, question, llm_output=None) -> List[LFPlanResult]:
         """ developer can invoke llm guided by prompt to genrate LFPlanResult"""
        pass
```

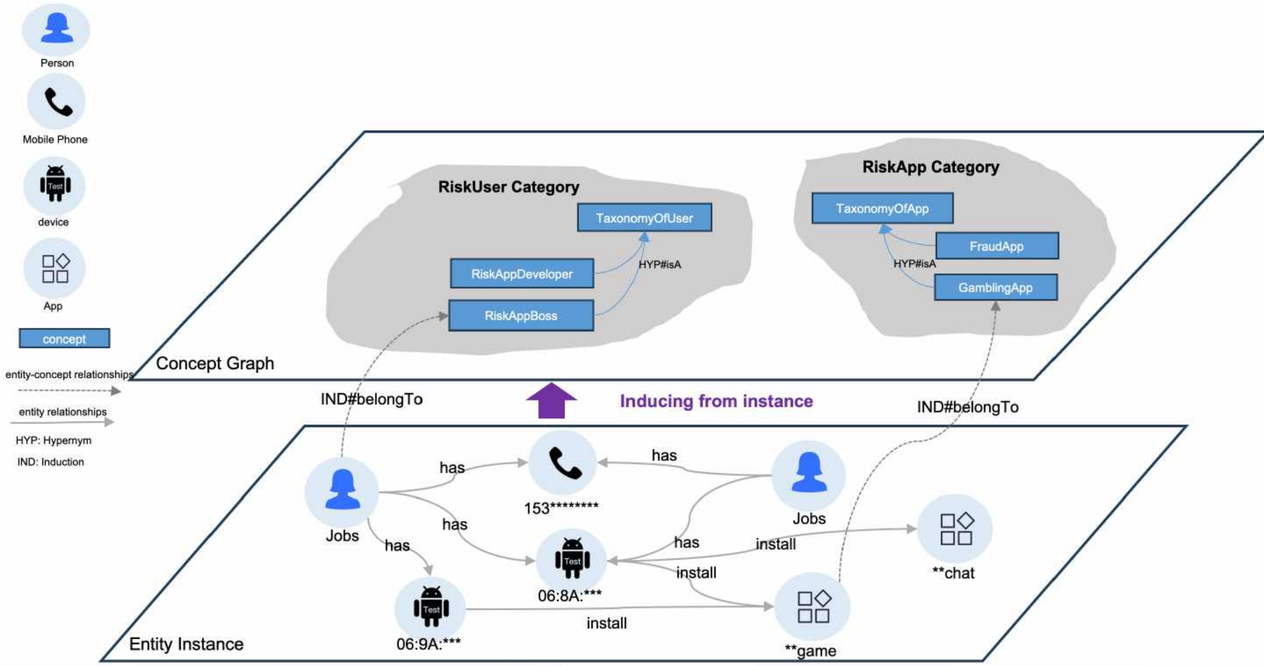
LogicForm Solver interface

```
class LFSolver:
    """
    kg_retriever recall subgraph through graph pattern match on kgdsl
    chunk_retriever recall Chunk by combining ppr & dpr
    """
    def __init__(self, kg_retriever: KGRetrieverABC = None,
                 chunk_retriever: ChunkRetrieverABC = None,
                 report_tool=None, **kwargs):
        pass

    def solve(self, query, lf_nodes: List[LFPlanResult]):
        """
        Returns:
        tuple: A tuple containing the final answer, sub-query-answer pairs,
        relevant documents, and history.
        """
```

基于KAG自定义严谨决策（示例-黑产图谱）

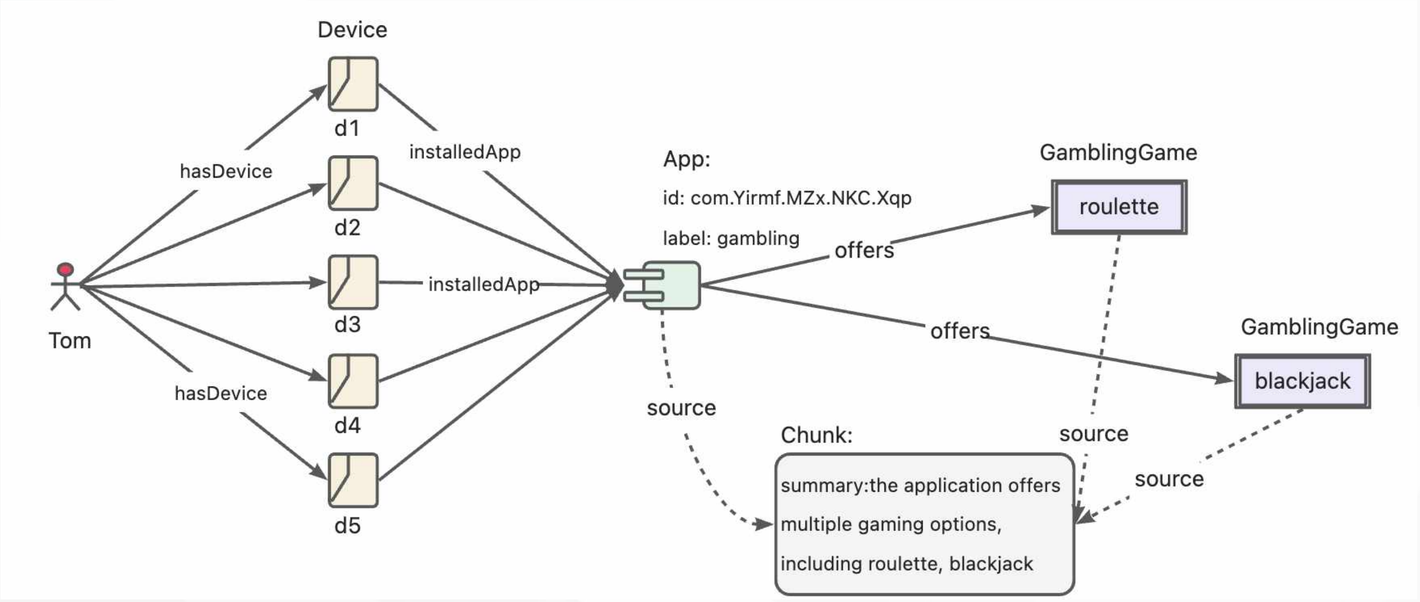
黑产图谱，通过提升黑产特征挖掘、完善黑产团伙刻画、推送线索助力司法部门线下打击等手段，降低体系内赌博电诈风险。其主要挑战在于：

- 领域专家规则与业务数据的统一建模
- 灵活的知识架构，以匹配适应多风险场景



基于SPG语义表示自定义专家规则

RC & KG_{fr} & KG_{cs}



define riskAppTaxo rule ① 定义"赌博App" 规则

```
Define (s:App)-[p:belongTo]->(o:`TaxOfRiskApp`/`GamblingApp`) {
    Structure {
        (s)
    }
    Constraint {
        R1("risk label marked as gambling") s.riskMark like "%Gambling%"
  }
}
```

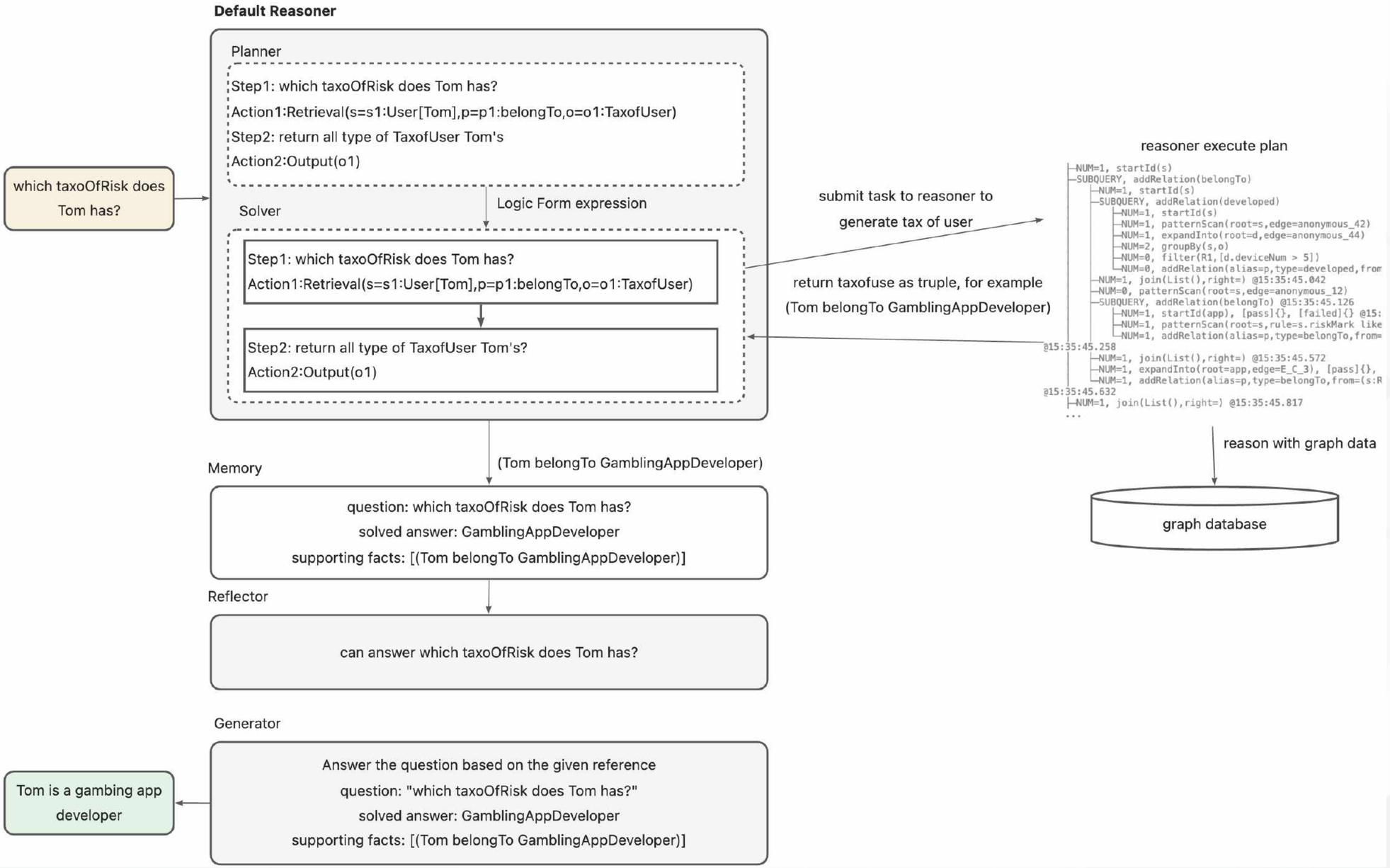
define app developper rule ② 定义"App开发者" 规则

```
Define (s:Person)-[p:developed]->(o:App) {
    Structure {
        (s)-[:hasDevice]->(d:Device)-[:install]->(o)
    }
    Constraint {
        deviceNum = group(s,o).count(d)
        R1("device installed same app"): deviceNum > 5
    }
}
```

define a RiskUser of gambling app rule ③ 定义"赌博App开发者" 规则

```
Define (s:Person)-[p:belongTo]->(o:`TaxOfRiskUser`/`DeveloperOfGamblingApp`) {
    Structure {
        (s)-[:developed]->(app:`TaxOfRiskApp`/`GamblingApp`)
    }
    Constraint {
    }
}
```

Kag-Solver决策流程 & 结果

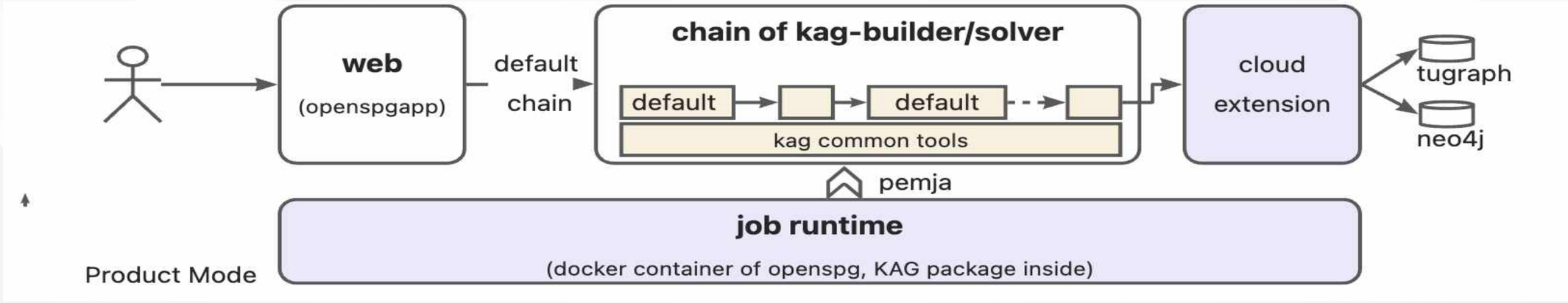


部署 & 使用

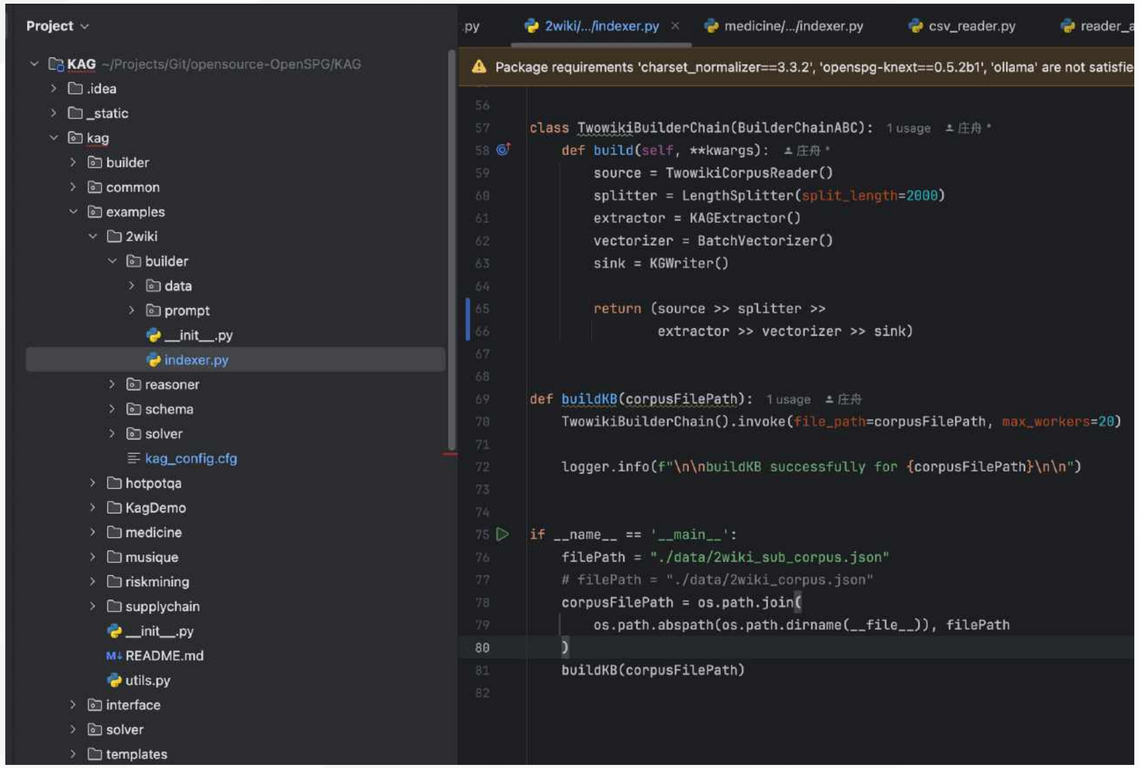
部署&使用（产品模式）

产品模式：readme

- kag default schema + default builder chain
- Openspg provides runtime env for Kag-builder chain through pemja
- kag-builder call API of openspg server for dumping extraction result to graph-engine

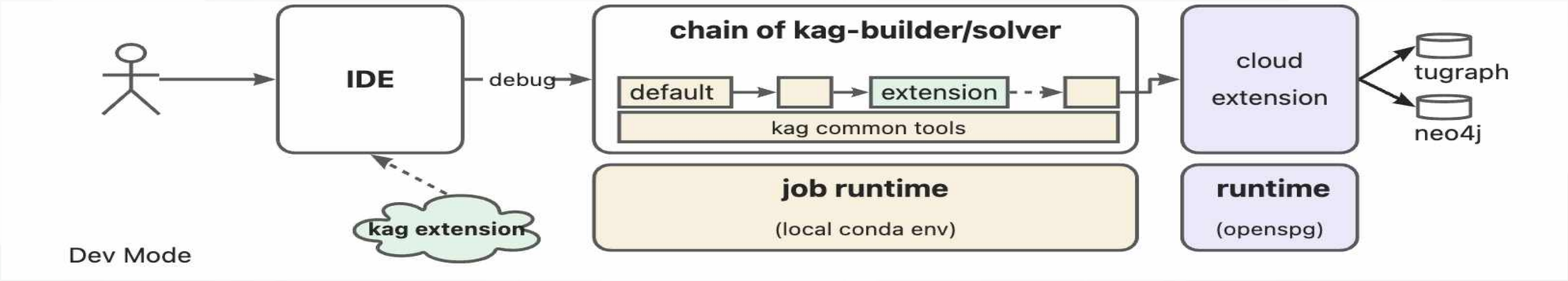


部署&使用（开发者模式）



开发者模式：readme

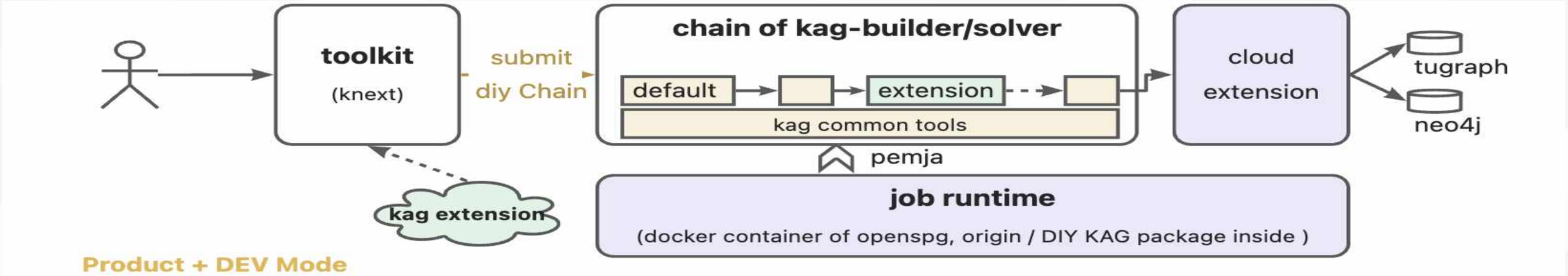
- developer customize schema & builder chain
- Local python IDE provides runtime env for Kag-builder chain
- kag-builder call API of openspg for dumping extraction result to graph-engine



部署&使用（产品能力定制化）

产品能力定制化: release soon

- 开发者模式完成自定义扩展的能力校验
- 任务提交到 openspg-server 执行



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KAG 典型应用

Kag 内置案例

```
kag
├── examples
│   ├── 2wiki
│   ├── hotpotqa
│   ├── medicine
│   ├── musique
│   ├── riskmining
│   │   ├── builder
│   │   │   ├── data
│   │   │   └── indexer.py
│   │   ├── kag_config.cfg
│   │   ├── reasoner
│   │   │   ├── client.py
│   │   │   └── gambling_app.dsl
│   │   ├── schema
│   │   │   ├── RiskMining.schema
│   │   │   └── concept.rule
│   │   └── solver
│   │       ├── prompt
│   │       └── qa.py
│   │
│   └── supplychain
```

Framework	Model	HotpotQA		2WikiMultiHopQA		MuSiQue	
		EM	F1	EM	F1	EM	F1
NativeRAG [24, 23]	ChatGPT-3.5	43.4	57.7	33.4	43.3	15.5	26.4
HippoRAG [6, 23]	ChatGPT-3.5	41.8	55.0	46.6	59.2	19.2	29.8
IRCoT+NativeRAG	ChatGPT-3.5	45.5	58.4	35.4	45.1	19.1	30.5
IRCoT+HippoRAG	ChatGPT-3.5	45.7	59.2	47.7	62.7	21.9	33.3
IRCoT+HippoRAG	DeepSeek-V2	51.0	63.7	48.0	57.1	26.2	36.5
KAG (ours)	DeepSeek-V2	**62.5**	**76.2**	**67.8**	**76.7**	**36.7**	**48.7**

Table 9: The end-to-end generation performance of different RAG models on three multi-hop question answering datasets. Bold text indicates that the same base model performs best. NativeRAG and HippoRAG use single-step retrieval, while other models employ multi-step retrieval.

	Retriever	HotpotQA		2WikiMultiHopQA		MuSiQue	
		Recall@2	Recall@5	Recall@2	Recall@5	Recall@2	Recall@5
Single-step	BM25 [25]	55.4	72.2	51.8	61.9	32.3	41.2
	Contriever [26]	57.2	75.5	46.6	57.5	34.8	46.6
	GTR [27]	59.4	73.3	60.2	67.9	37.4	49.1
	RAPTOR [28]	58.1	71.2	46.3	53.8	35.7	45.3
	Proposition [29]	58.7	71.1	56.4	63.1	37.6	49.3
	NativeRAG [24, 23]	64.7	79.3	59.2	68.2	37.9	49.2
	HippoRAG [6, 23]	60.5	77.7	70.7	89.1	40.9	51.9
Multi-step	IRCoT + BM25	65.6	79.0	61.2	75.6	34.2	44.7
	IRCoT + Contriever	65.9	81.6	51.6	63.8	39.1	52.2
	IRCoT + NativeRAG	67.9	82.0	64.1	74.4	41.7	53.7
	IRCoT + HippoRAG	67.0	83.0	**75.8**	**93.9**	45.3	57.6
	KAG (ours)	**72.8**	**88.8**	65.4	91.9	**48.5**	**65.7**

Table 10: The performance of different retrieval models on three multi-hop question-answering datasets.

- Kag 示例的复现，可参考kag 用户手册: kag user manual
- 更多领域 (教育、维修、工业、医疗、事理图谱) 案例后续按计划发布

Kag蚂蚁应用

知识问答

分析写作

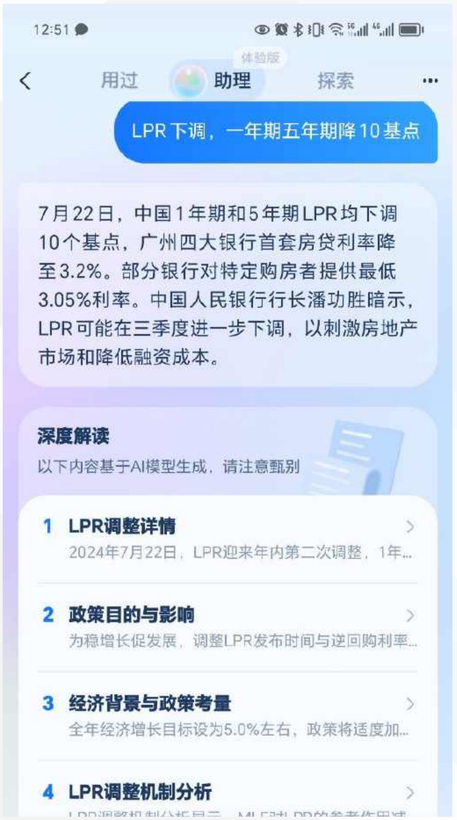
政务办事问答

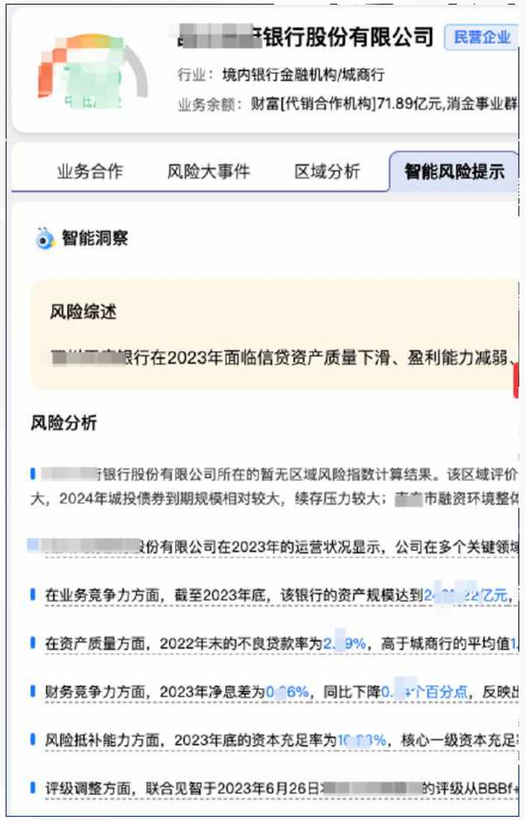
医疗健康问答

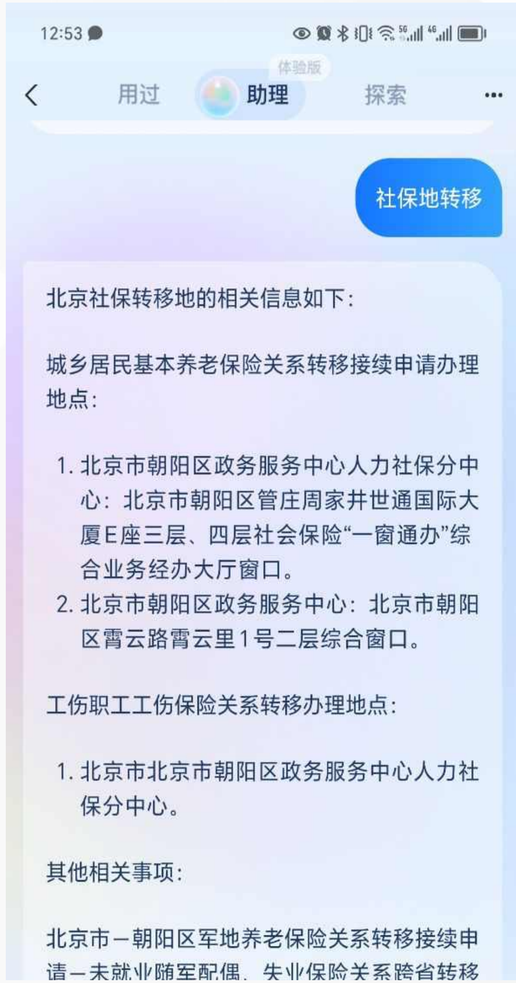
生活管家热点小报

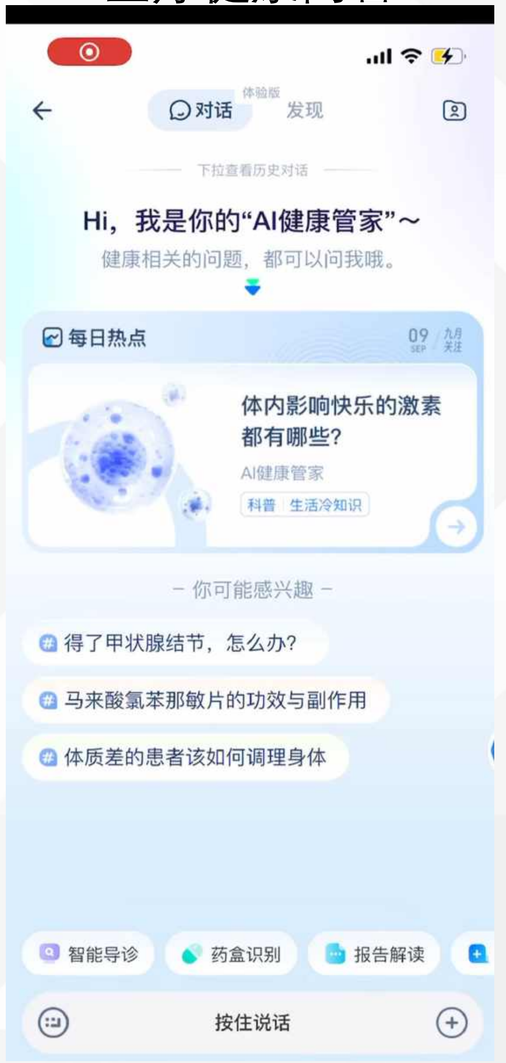
银行风险分析

保险事件带货









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OpenSPG-KAG 后续迭代计划

模块	能力项	发布节奏
产品交互优化	1、自定义schema 2、图分析查询 3、前端开源	参考OpenSPG官网发布计划
Kag-builder 优化	1、增量更新 完善 2、性能优化 3、垂直领域对齐及多种文档结构 4、分布式	
Kag-solver 优化	1、logical-Form 算子完备性 2、多任务问答 3、类o1	
Kag-model	1、kag model 发布	

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联系我们

KAG: https://github.com/OpenSPG/KAG
使用文档: ReadMe

(欢迎关注star)

(技术交流群)

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Thanks & QA