Xpert: Empowering Incident Management with Query Recommendations via Large Language Models

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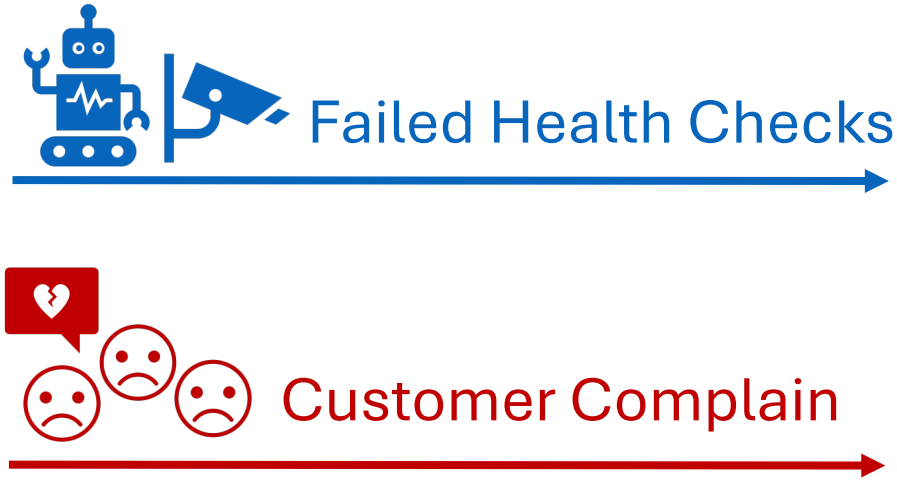
Cloud Incidents Produce Incident Tickets



Incident Tickets

Writing Queries is Crucial For Resolution

Incident Tickets

On-call Engineers (OCE)

KQL Query

Database table to query from

```
MonRdmsInstanceAgent
| where LogicalServerName == “fpgsqlserver”
| where msg_metadata contains “OpenNewConnection”
| project TIMESTAMP, msg_metadata, event, severity
| order by TIMESTAMP desc
```

Filtering operation

Telemetry Data (Traces, Logs, Metrics)

Diagnosis & Solution

Writing Correct Queries is Challenging

Task: Finding relevant data in **a haystack of databases.**

OCE

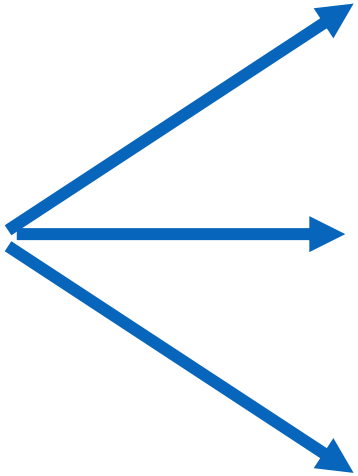
Telemetry Data

```
MonRdmsInstanceAgent
| where LogicalServerName == “fpgsqlserver”
| where msg_metadata contains “OpenNewConnection”
| project TIMESTAMP, msg_metadata, event, severity
| order by TIMESTAMP desc
```

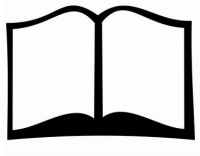
Writing Correct Queries is Challenging

Task: Finding relevant data in **a haystack of databases.**

OCE



Domain Experience



Troubleshooting Guide (TSG)

External Help

```
MonRdmsInstanceAgent
| where LogicalServerName == “fpgsqlserver”
| where msg_metadata contains “OpenNewConnection”
| project TIMESTAMP, msg_metadata, event, severity
| order by TIMESTAMP desc
```

Generating Queries is Immensely Helpful

- ~ 500 incidents daily on Azure for Top-30 services

New Incident Ticket

ID XXX	Title
ACTIVE	Summary
	Discussion
Severity x	...

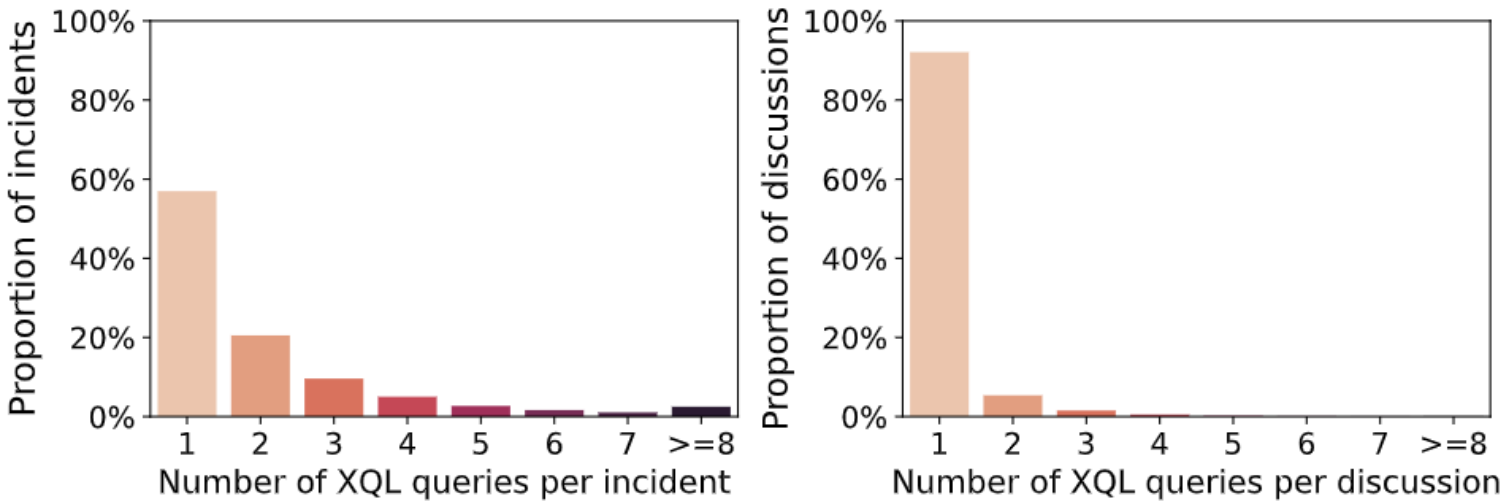
Automation?

```
MonRdmsInstanceAgent
| where LogicalServerName == “fpgsqlserver”
| where msg_metadata contains “OpenNewConnection”
| project TIMESTAMP, msg_metadata, event, severity
| order by TIMESTAMP desc
```

How to Generate Queries?

- What input do we need?
- Number of queries to generate for each incident?
- How to guarantee queries are executable?
- …

RQ1: Frequency of Queries



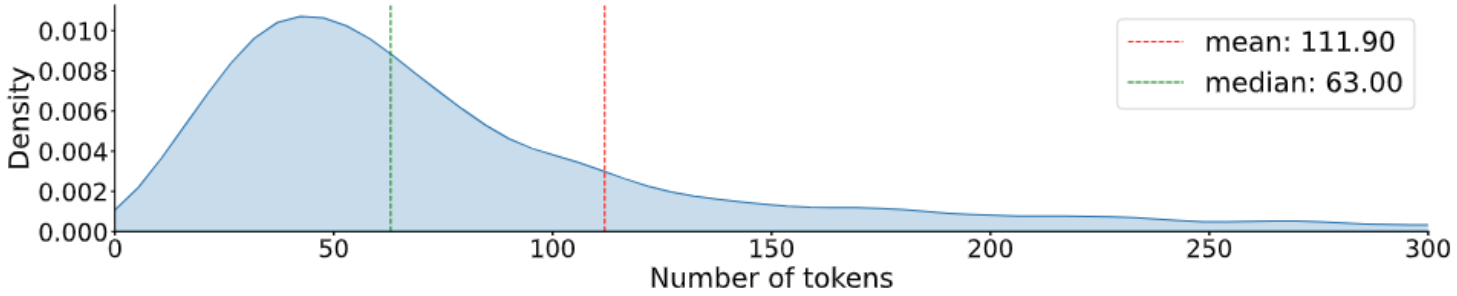
Study Result:

- Over half of the incidents have only one Kusto query.
- Over 90% of the discussions within an incident contain just one query.

Design Implication:

- **Recommending one query suffices.**

RQ2: Complexity of Queries



64 tokens:

```
VMApiQosEvent
| where PreciseTimeStamp >= ago(1d)
| where errorDetails contains "AllocationError"
| where MonitoringApplication contains "Service A"
| project PreciseTimeStamp, operationId, vMSize, errorDetails
| order by PreciseTimeStamp desc
| take 10
```

Study Result:

- Median of tokens per query is 63, average tokens are ~112.
- Majority of incidents are managed using relatively concise Kusto queries.

Design Implication:

- **Query generation can be feasible.**

RQ3: Diversity of Queries

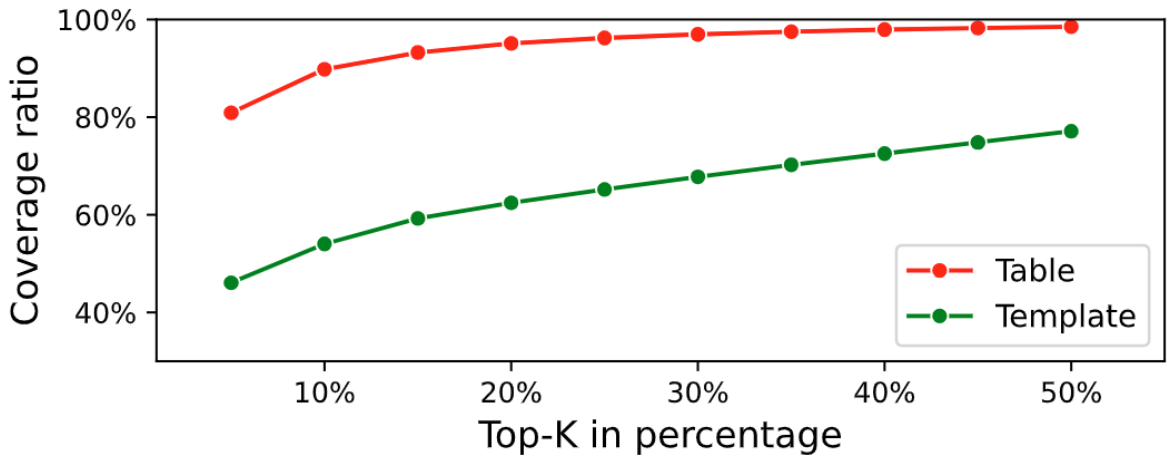
Table

XQL Query

```
VMNodeMeta
| where date > ago(1d) and date < now()
| where region == "west us"
| join kind = leftouter
LatencyEvolution on NodeId
| summarize AvgDelay = avg(delay) by NodeId
| where AvgDelay > 1
| order by AvgDelay
| take 10
```

XQL Query Template

```
VMNodeMeta
| where date > ago({timespan}) and date < {time}
| where region == {string}
| join kind = leftouter
LatencyEvolution on NodeId
| summarize AvgDelay = avg(delay) by NodeId
| where AvgDelay > {int}
| order by AvgDelay
| take {int}
```



Study Result:

- KQL usage exhibit low-diversity.
  - 80.9% queries use 5% of all tables.
  - 46.1% queries consist of 5% unique templates.
- KQL usage differs across services.

Design Implication:

- **Use similar incidents' queries to guide query generation.**

RQ3: Diversity of Queries

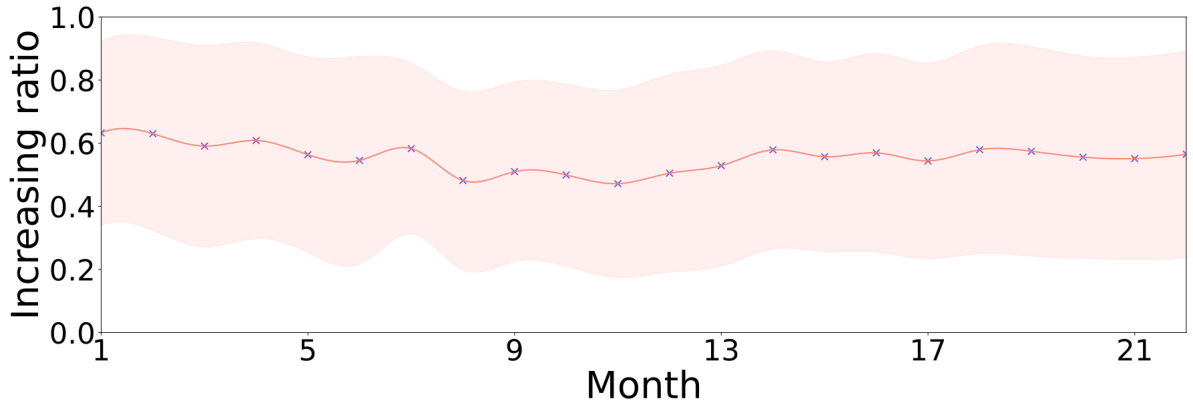


Figure 5: The mean±std. of the monthly ratio of KQL queries covered by novel templates across all services.

Study Result:

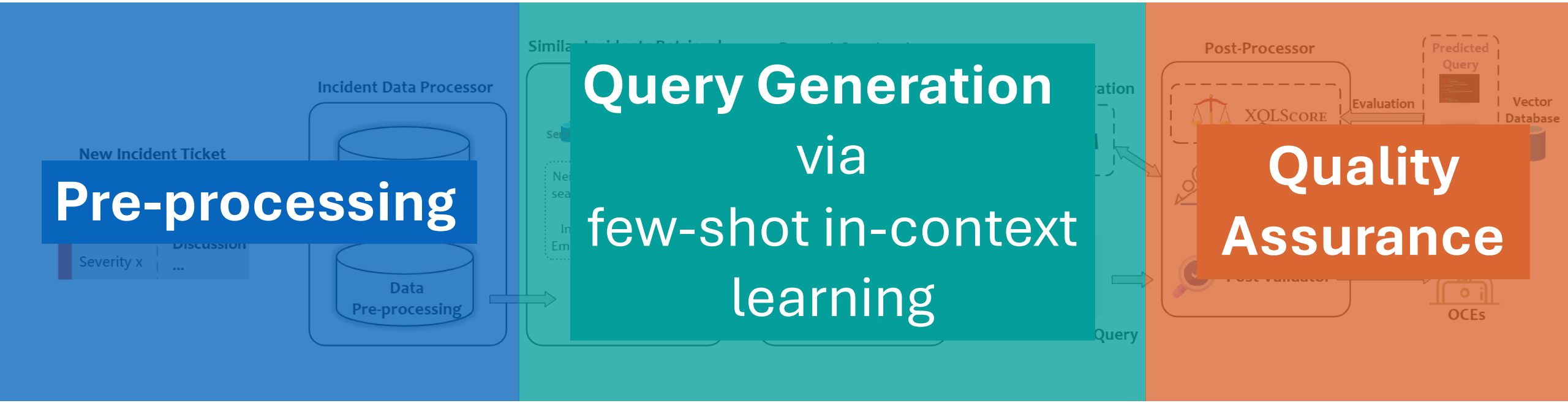
- KQL usage change significantly over time (>60% per month).

Design Implication:

- **Model training/finetuning might not be feasible.**

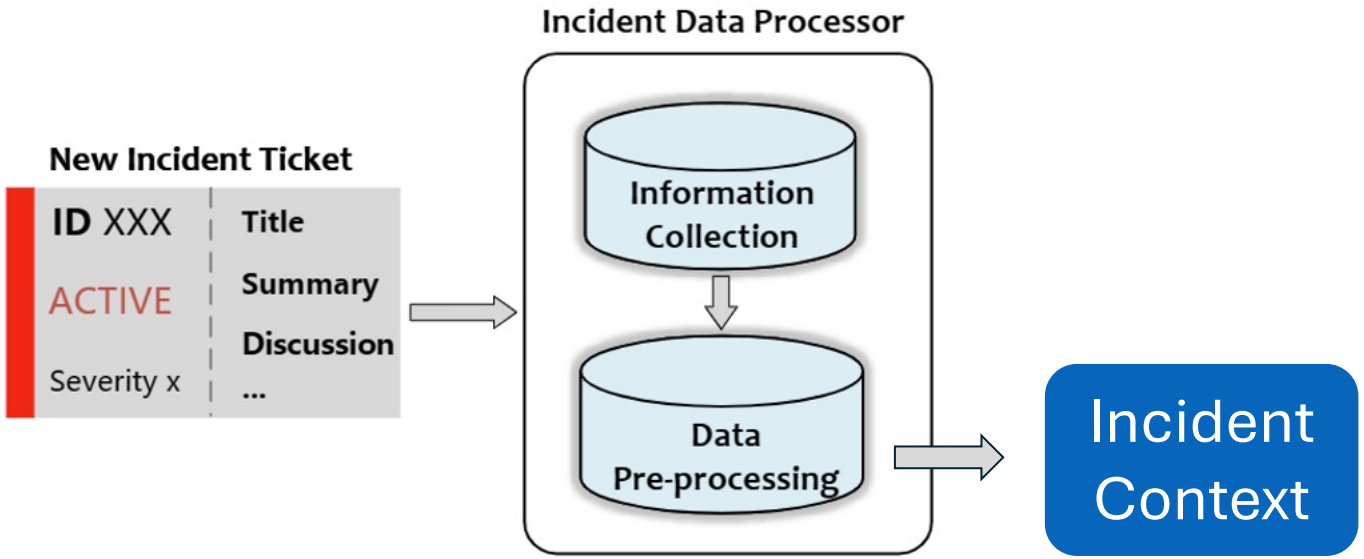
Solution

Xpert: An End-to-End Query Generation Framework



- **End-to-End Automated Query Generation**
- **Pattern Extraction from Abundant Historical Incidents**
- **Customized Recommendations for New Incidents**

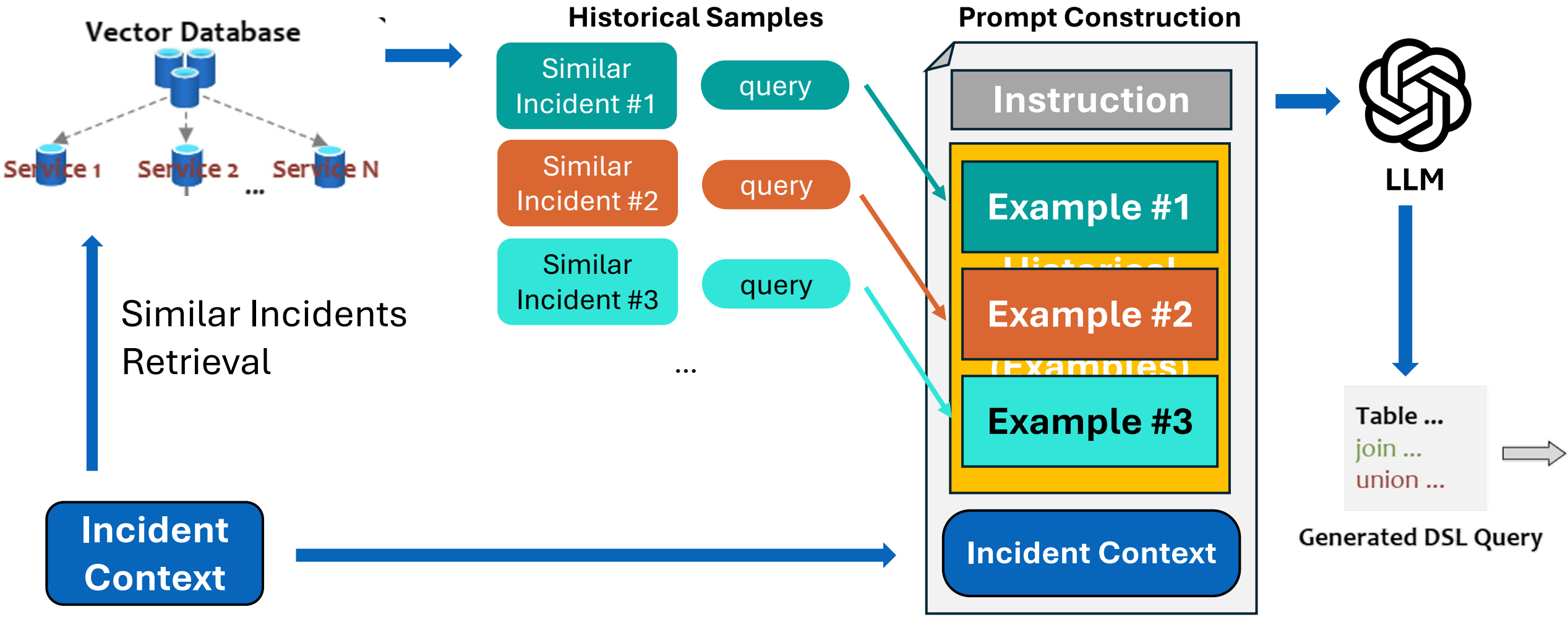
Data Pre-Processor



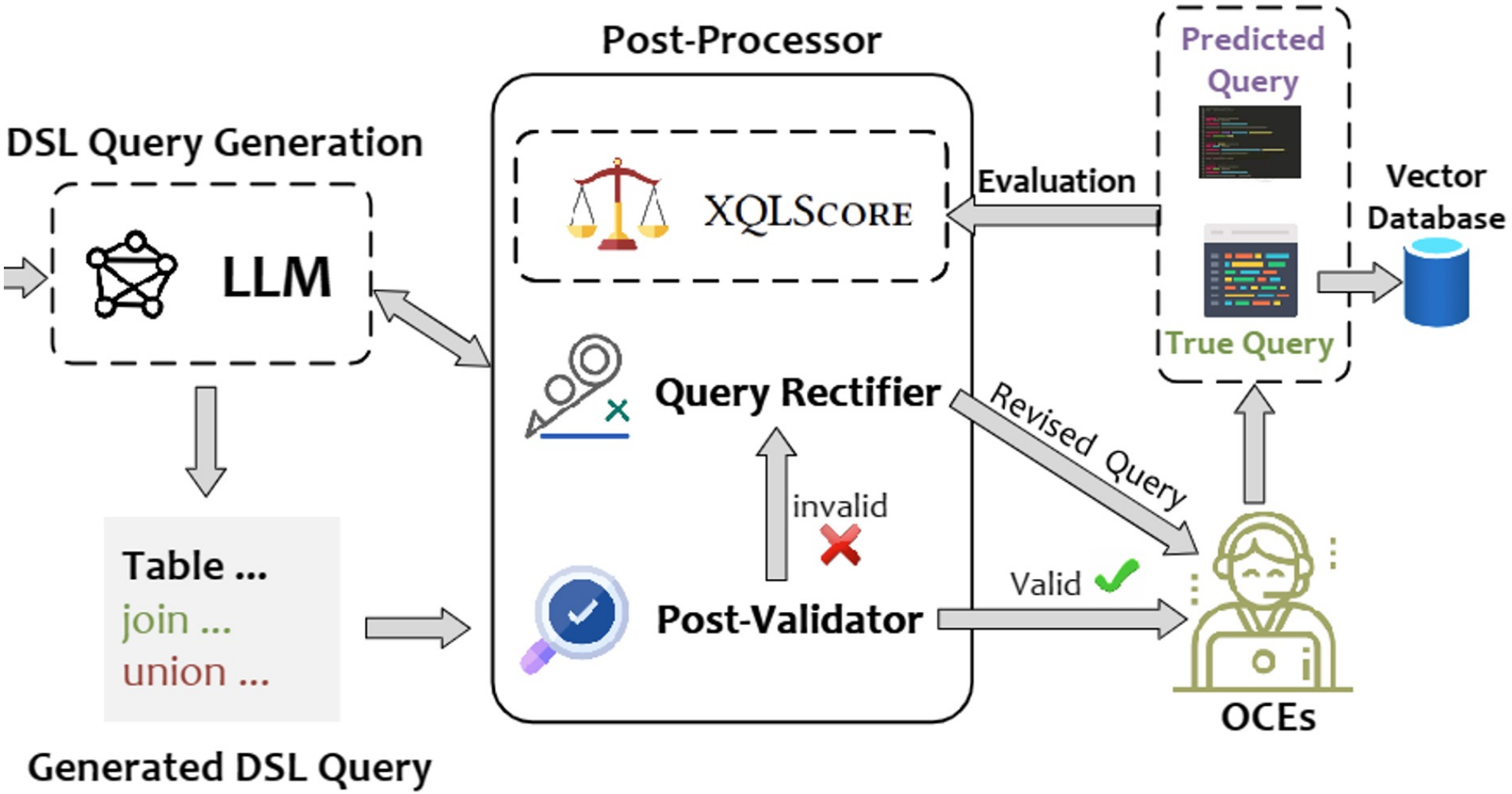
- **Metadata**
  - Timestamp
  - Error Message
- **Title**
- **Summary**
  - Impact of outage
- **Discussion**
  - Attempted diagnosis
  - Additional outage description

Query Generation: Few-shot in-context learning

Design Implication: Use similar incidents' queries as reference.



Post Processor



Evaluating Generated Queries Without Execution

	Ground Truth	Generated Sample
1	Errors	JobErrors
2	| where TIMESTAMP >= datetime(2022-03-27 22:04:06Z)	| where TIMESTAMP < datetime(2022-03-27 22:04:06Z)
3	| where SourceNamespace contains “us-east”	| where SourceNamespace contains “us-east”
4	| where Deployment == “svc-mesh-3d21”	| where Deployment = “svc-mesh-3d21”
5	| summarize count() by subscriptionId	| summarize count(subscriptionId)

Tables do not match

`<` is opposite to `>=`

Invalid op `=`

Effectively two different statements

- NLP metrics overlook syntax & semantic properties in code.
  - BLEU: 75.67, METEOR: 87.02 → **The generated query seems to be very good!**

Syntax & semantics should be considered in evaluation.

Evaluation with Xcore

Xcore: 3.54 for the previous example

Syntax and Semantic Check

Ensure query is executable

Examples:

```
| project colB, colC
| sort by colA asc
```

All columns except for **colB**, **colC** are excluded from the data flow.

Sub-component Matching

Canonicalize query for lexical comparison

```
where A and B
```

and

```
where B and A
```

should be considered equivalent

Output Schema Matching

Approximate execution result

```
Errors
| where TIMESTAMP >= ago(1d)
| where Name == “svc-3d21”
| project Name, FailureReason
```

would have output schema

Column	**Name**	**FailureReason**
DType	**String**	**Unknown**

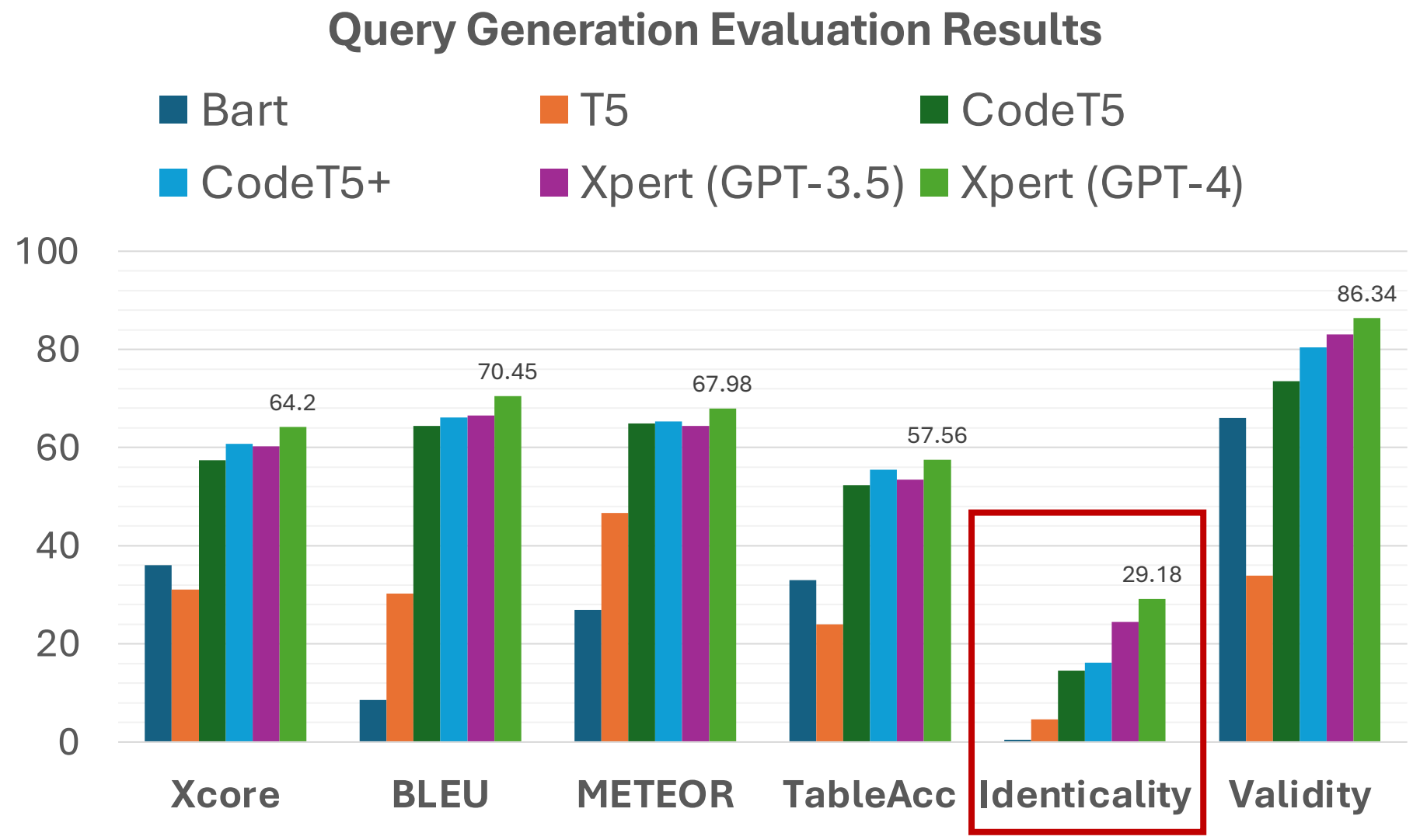
Evaluation: Xpert

- **Baseline Models**: Finetuned transformer models (T5, Bart, CodeT5, CodeT5+)
- **Dataset**: ~200,000 samples for retrieval; 3,000 samples tested across top-10 tenants

- **Task:**
  Generating queries for the 3000 samples.
  - Xpert will use **historical incidents for reference**, while
  - baselines are **finetuned** and perform **zero-shot generation**.

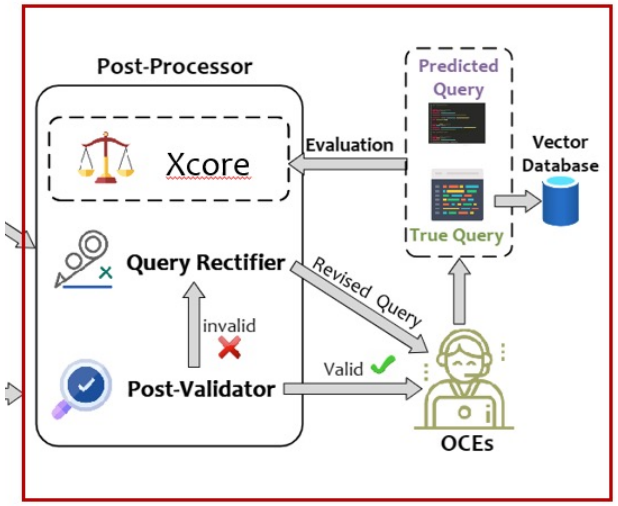
Solutions are assessed by comparing the generated query with the ground truth.

Evaluation: Overall Performance

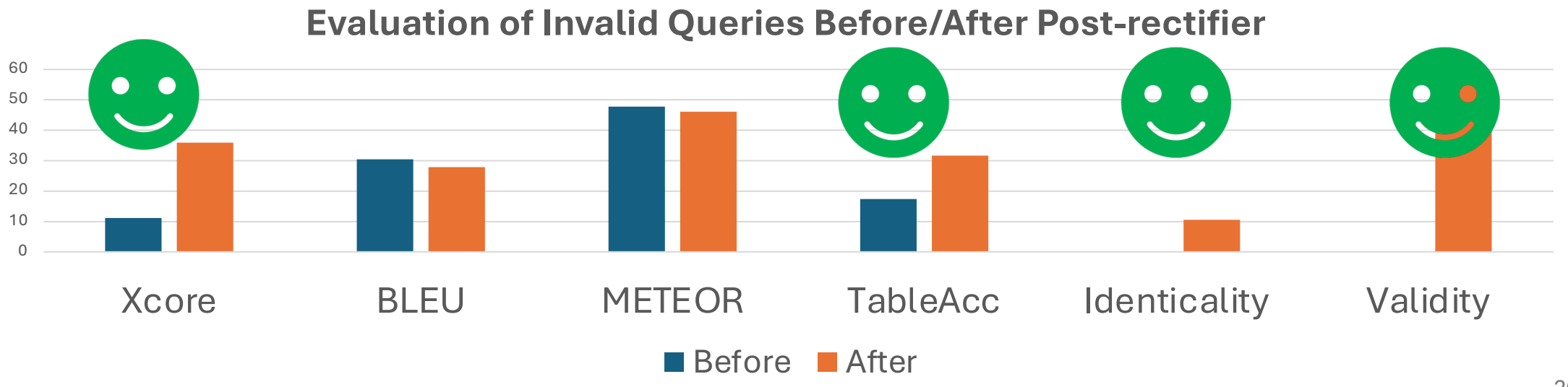


- **Xpert (GPT-4) is the best across all metrics**
- **Xpert (GPT-3.5) are comparable with CodeT5+**
- **Greater advantage on identicality:**
  - Xpert: 29.19%
  - Finetuned Models: 16.18%

Evaluation: Post-processor



- Post-rectifier improves the prediction quality for most of performance dimensions
- Refining over **50%** queries to valid



Summarizing Xpert

- **Pioneering Empirical Study**: Investigating the application of query languages in incident management systems.
- **Innovative Framework**: Introducing *Xpert* for automated generation of incident management queries.
- **Novel Metric**: *Xcore*, assessing query quality independently of the execution environment.
- **Proven Deployment**: Validating *Xpert's* effectiveness through practical implementation in a real-world setting.

Related Works

- **Text2SQL Adaptation:**
  - Moves beyond direct natural language translation.
  - Tackles unstructured, noisy input interpretation.
  - Enhances Text2SQL to aid in root cause analysis from symptomatic data.
  - Showcases the utility of in-context learning for complex queries.

- **Advancements in AIOps:**
  - Aligns with AI-driven IT operational enhancements.
  - Demonstrates AI's role in streamlining incident management.