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DATA AND AI/ML EDITION
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Extracting meaningful radiology insights from natural language using Amazon Comprehend Medical

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Amazon Web Services

Agenda

- What sort of *insights* are we talking about ?
- Why *natural language* ?
- Working backwards from insights to raw data
- Scaling to millions of examinations per year
- Early results
- Demonstration
- Next steps

What sort of *insights*?

Why are we waiting ?

- Demand for advanced imaging like MRI is growing.

- The common perception is that under-investment in imaging equipment and medical radiology technicians is the main cause of increasing patient wait times for scans.

- *But*, a 2021 MRI improvement programme identified under-utilization of people and equipment, as a major factor.

- Using data-driven insights, that programme optimized scheduling and workflow, delivering a 75% reduction in MRI wait times. Improvements were realized in months – not years.

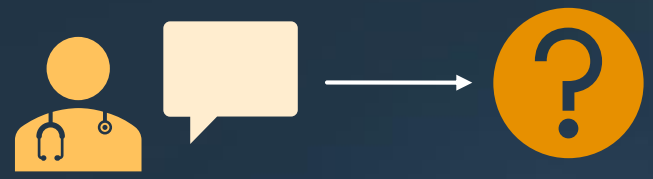
Scaling up is never easy (in healthcare)

- Radiology Information Systems (RIS) capture ordering and billing information in structured data formats.

- *But*, the content of radiology report is mainly transcribed natural language text that describes procedures, findings and conclusions.

- Conventional search approaches can produce misleading results within the specialized domain of clinical notes, due to the extensive use of negative statements and implied terms.

▶ Challenge #1



High quality interpretation of natural language.

Scaling up is never easy (in healthcare)

- In New Zealand, and many other countries, RIS implementations can vary from hospital to hospital.
- Interoperability standards like FHIR, and clinical terminology standards like SNOMED CT and LOINC are gradually being adopted…
- But widespread implementation is years away.

▶Challenge #2

Interoperability - aggregating data sets at a regional and national scale - **today**.

Scaling up is never easy (in healthcare)

- Demand for radiology services is dynamic.
- The capacity to deliver those services is dynamic.
- Factors affecting utilization of that capacity are dynamic.
- So a scaled up programme needs to be observable at the granularity of days, not months or years.

▶Challenge #3

Continuous improvement

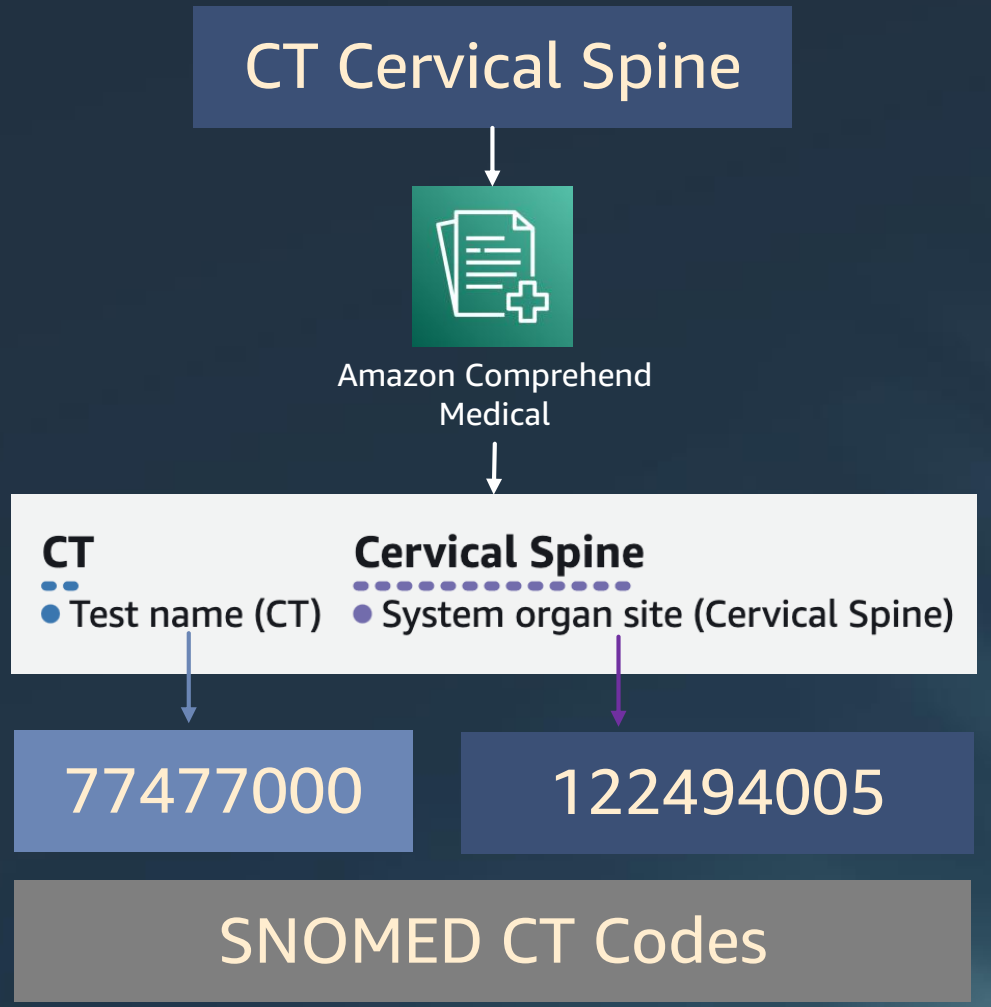
Why natural language processing (NLP) ?

Amazon Comprehend Medical

Amazon Comprehend Medical uses natural language processing (NLP) models to detect entities.

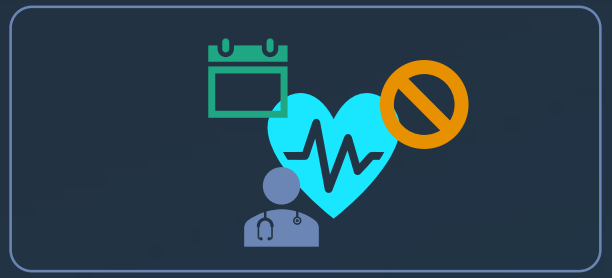
Entities are textual references to medical information such as medical conditions, medications, anatomy, procedures, tests, treatments, or protected health information.

Amazon Comprehend Medical provides APIs that can optionally link these detected entities to standardized medical knowledge bases such as SNOMED CT and ICD-10-CM through ontology linking operations.



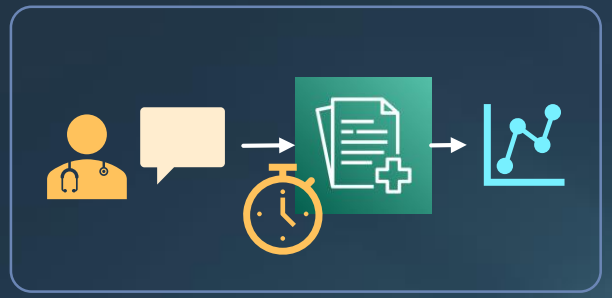
Using NLP to Solve The Scaling Challenges

Data Quality: Amazon Comprehend Medical detects the context in which an entity is used. For example – is it a diagnosis, a negation, or an historical reference?



Interoperability: Aggregating the plain text content of radiology reports from multiple incompatible Radiology Information Systems is straightforward.

Continuous Improvement: As an always-on AWS-managed service, Amazon Comprehend Medical can be invoked as soon as new reports are transcribed, making insights available in near-real-time.



Working Backwards

A set of specific questions for the proof-of-concept

The clinical sponsor set these 5 specific questions for the Radiology Insights proof-of-concept:

1. "***What proportion of CT renal tract examinations are positive for kidney or ureter stones?***"
2. "*What proportion of CT cervical spine examinations performed for trauma are positive for fracture?*"
3. *"What proportion of GP/community requested CT head examinations are abnormal?*"
4. "*Which examinations were performed under general anaesthetic?*"
5. "*Which examinations are image guided procedures such as injections or biopsies - as opposed to diagnostic?*"

The Raw Input

Structured Booking Data

Radiology Information System

Reference: K22268491

Date: 12/10/2022

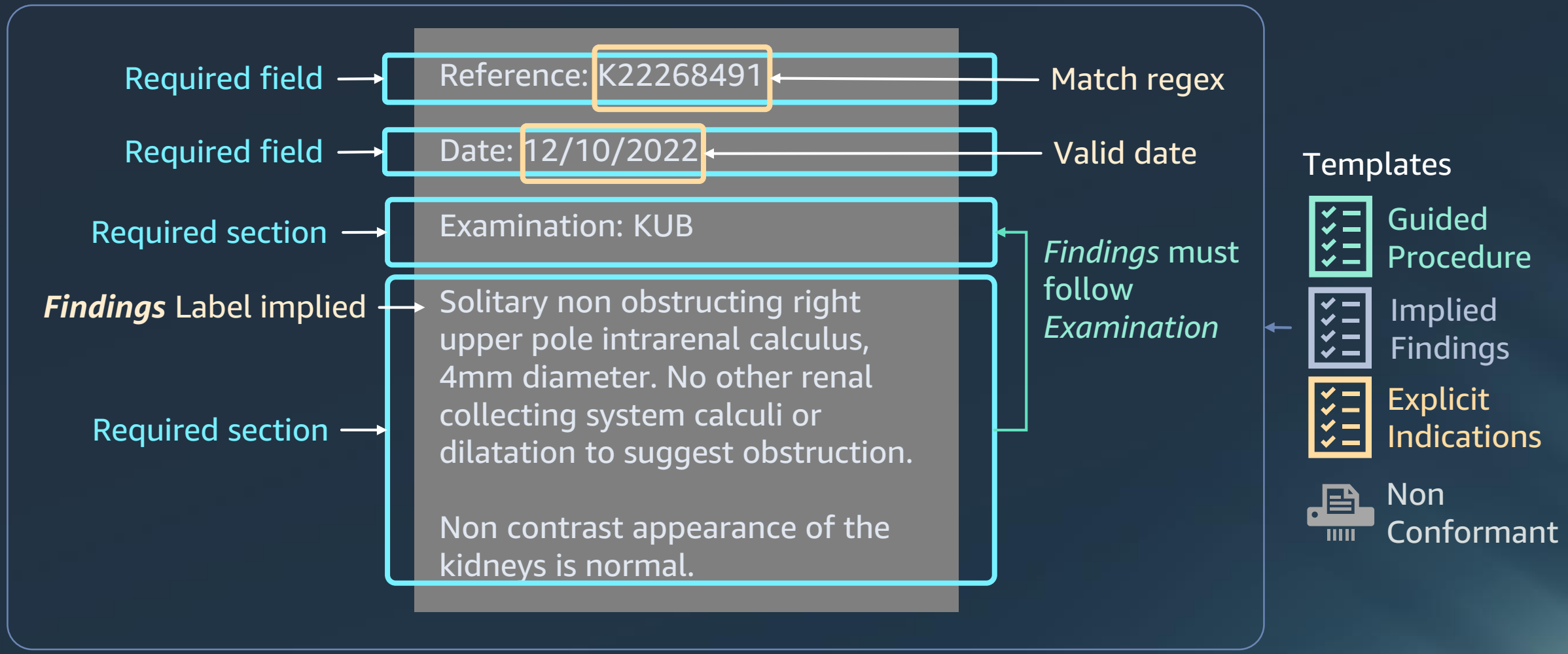
Examination: KUB

Solitary non obstructing right upper pole intrarenal calculus, 4mm diameter. No other renal collecting system calculi or dilatation to suggest obstruction.

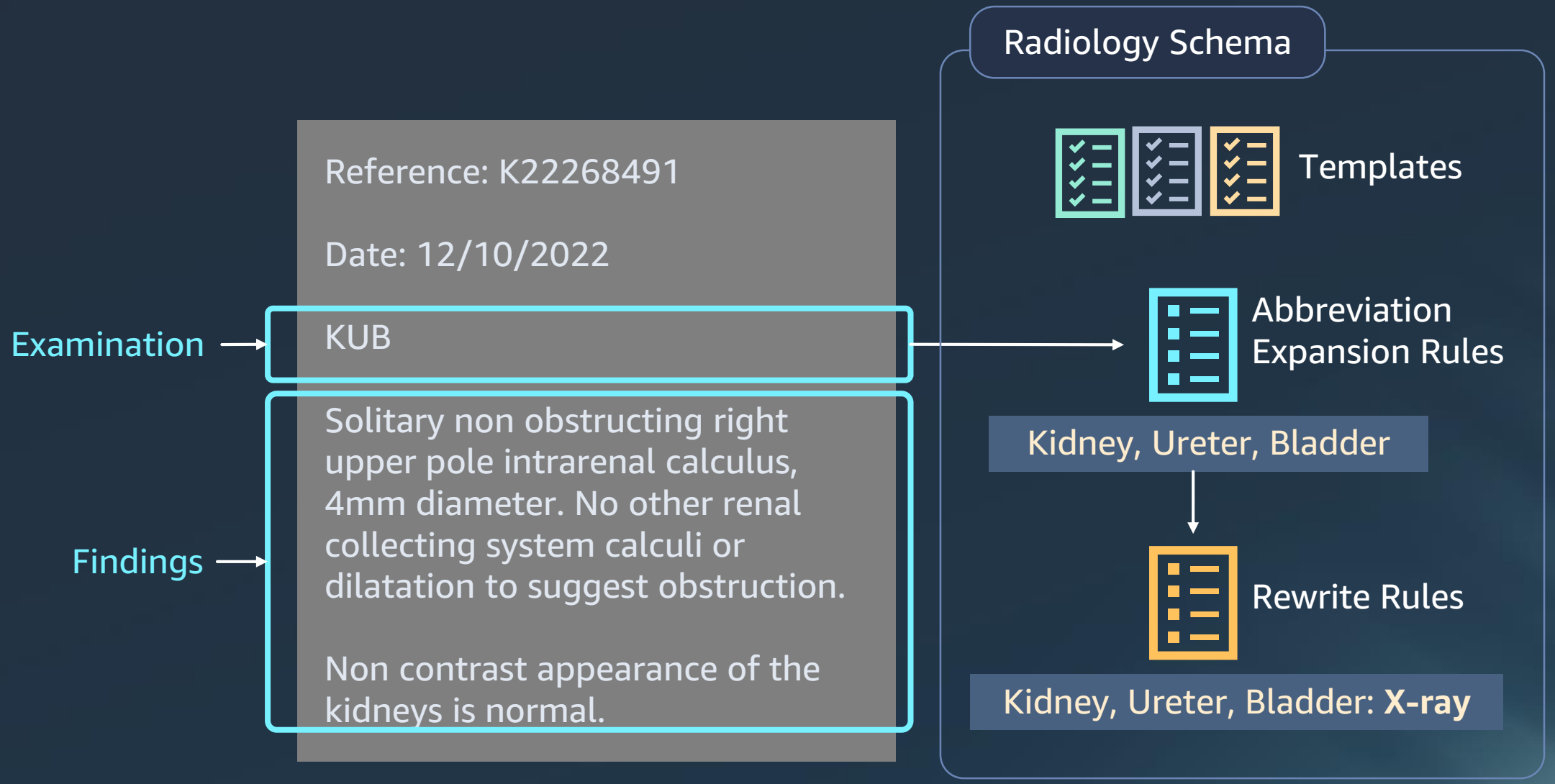
Non contrast appearance of the kidneys is normal.

Sample Radiology Report Text Content (simplified)

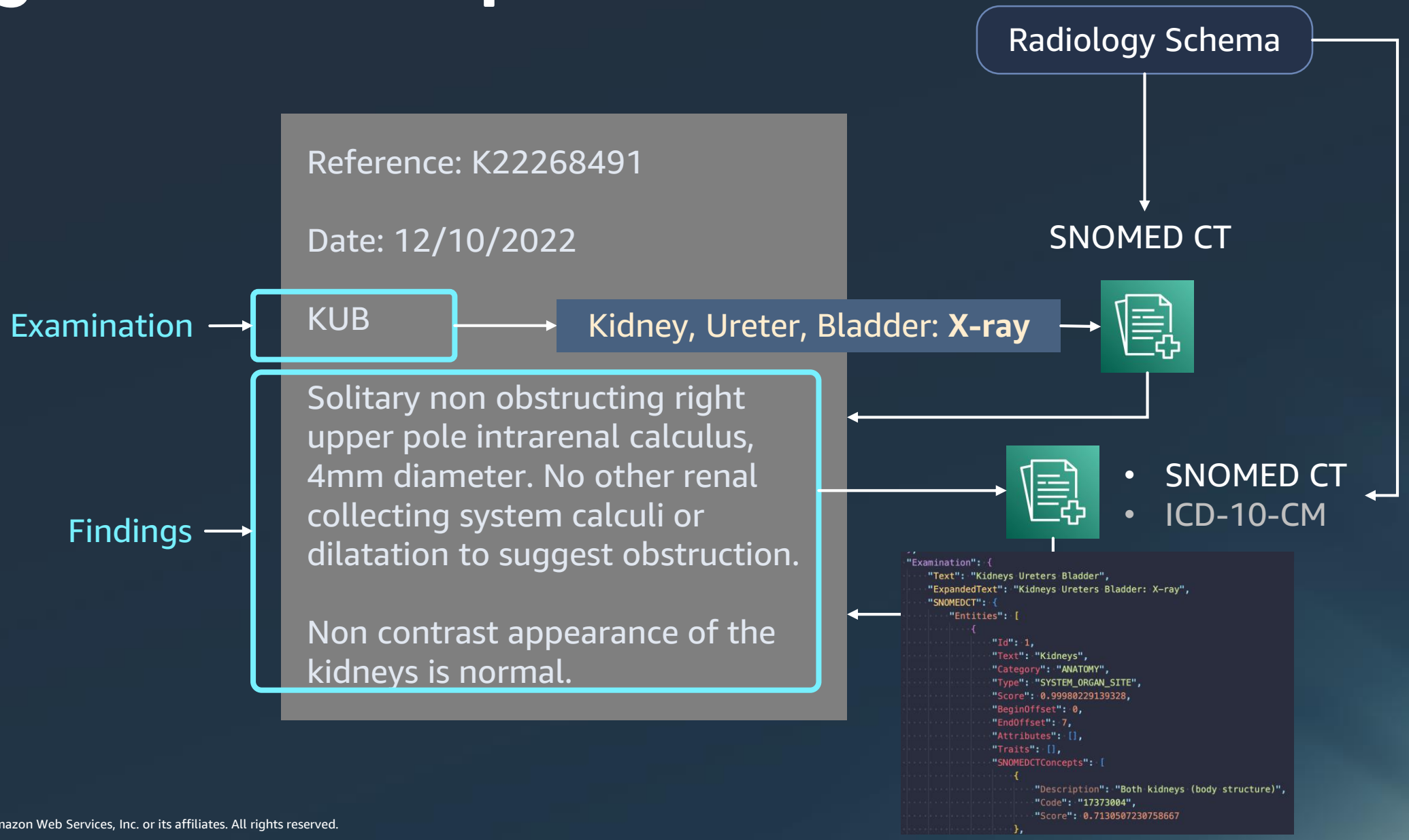
Input Validation



Pre-Inference Transforms



Calling Amazon Comprehend Medical



Standard Terminology

Reference: K22268491

Date: 12/10/2022

KUB

Solitary non obstructing right upper pole intrarenal calculus, 4mm diameter. No other renal collecting system calculi or dilatation to suggest obstruction.

Non contrast appearance of the kidneys is normal.

Entity #8

Category: Medical Condition
Traits:
- Negation: 0.67

Entity #6

Category: Medical Condition
Traits: None

SNOMED CT #6.1

Description: Kidney stone (disorder)
Code: 95570007
Confidence: 0.74

Medical Query Language

```
"Select": [
    "Reference", "DateOfExam", "Code",
    "Description", "Negation", "Section",
    {"Name": "Status", "Source": "Tag"}
],
"From": "SNOMEDCT",
"Where": [
    { "Path": "Findings",
     "Model": ":StoneNegative"
    },"EITHEROR",
    { "Path": "Findings",
     "Model": ":StonePositive"
    }],
"Join": {
  "ByCode": true,
  "ByStatus": false,
  "StatusBias": 1.0
}
```

Table columns

```
"StoneNegative": {
  "Category": "Medical Condition",
  "Contains": [[
   ["kidney", "OR", "ureteric"],
   "AND", "/stone(s)?/",
   "AND", "(disorder)"
  ]],
  "MinScore": 0.75,
  "CodeMinScore": 0.7,
  "Traits": {
    "Negation": 0.6
  }
}
```

Logical operator

Regular expression

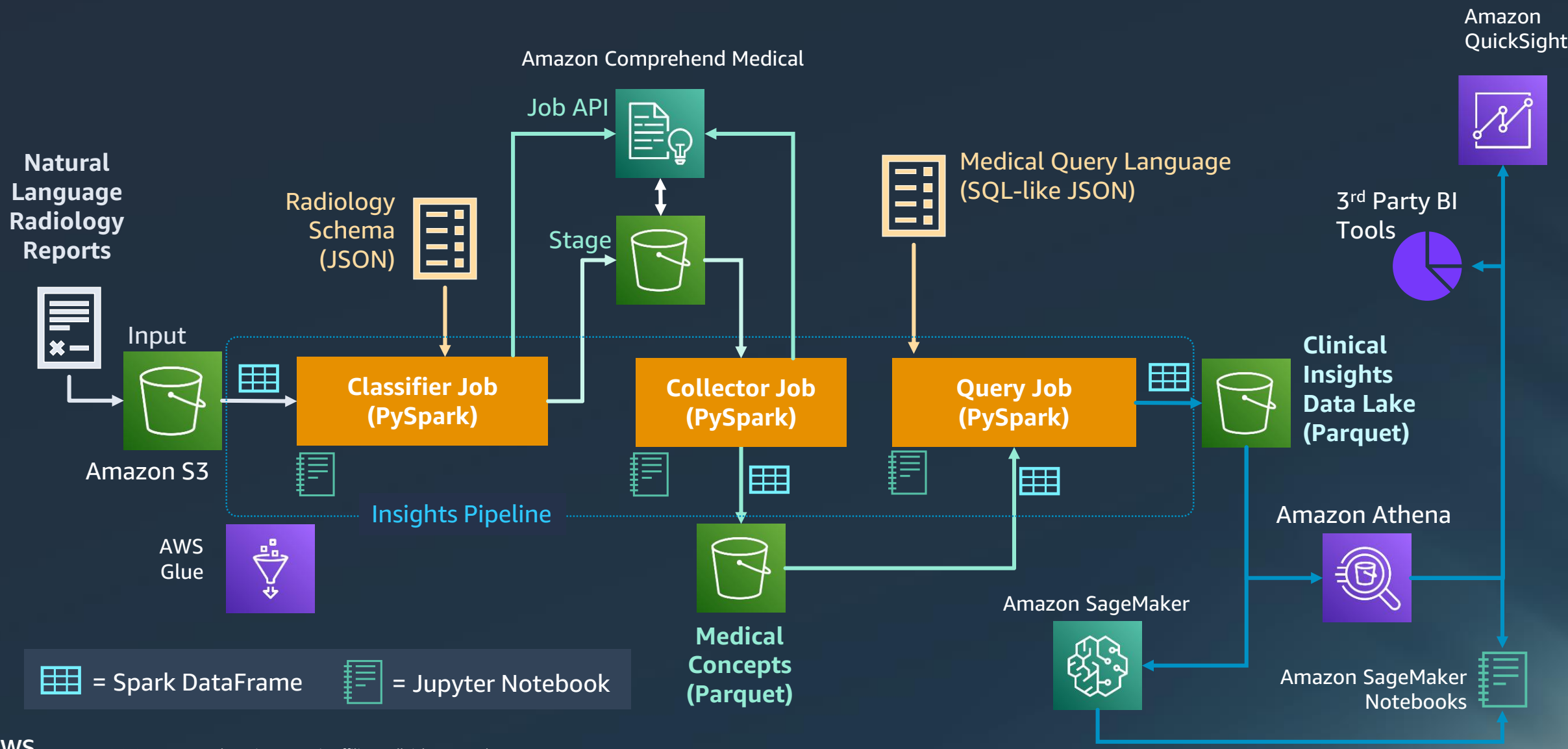
Confidence Thresholds

Require negations

Rules for resolving multiple matching entities into relational rows.

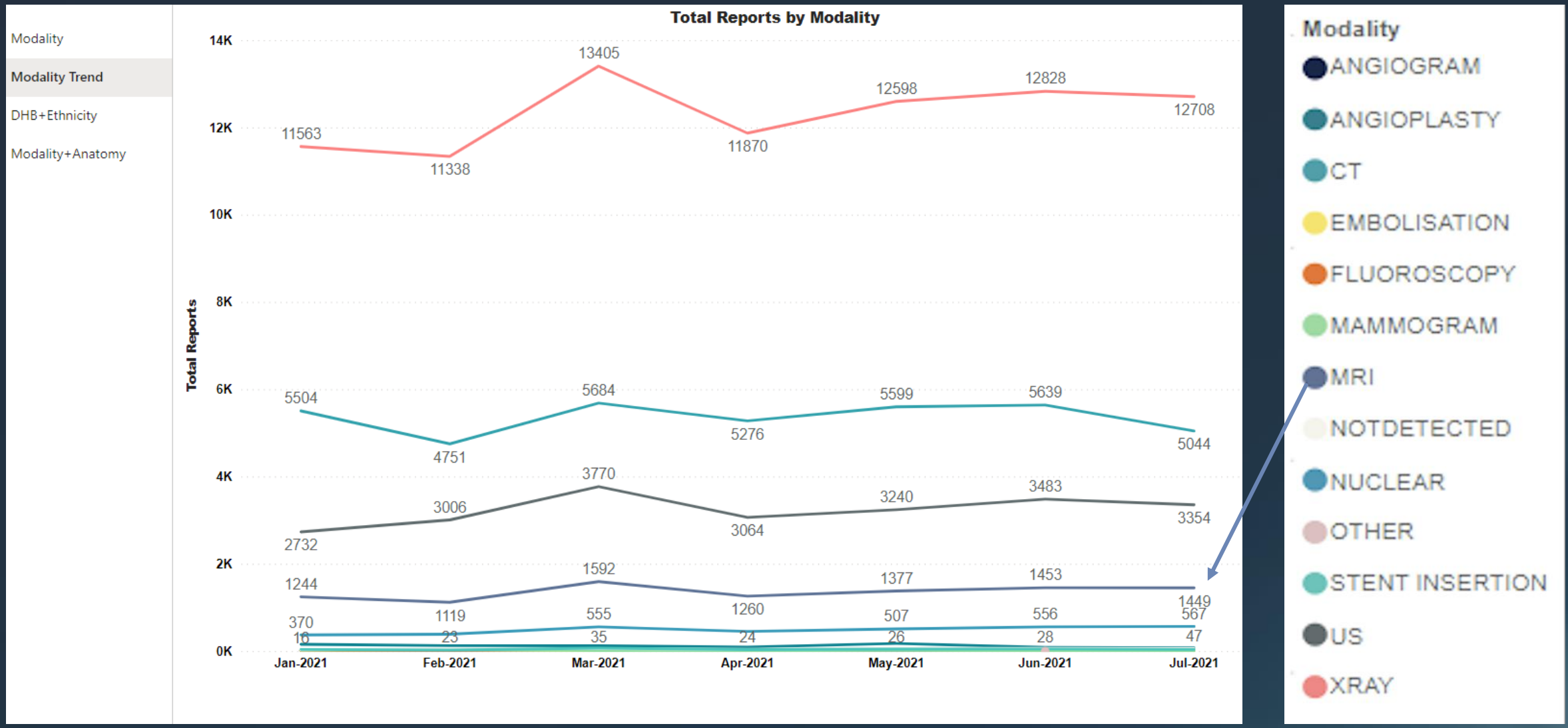
Scaling to Millions of Reports

Radiology Insights Pipeline Architecture



Early results

Production Visualizations



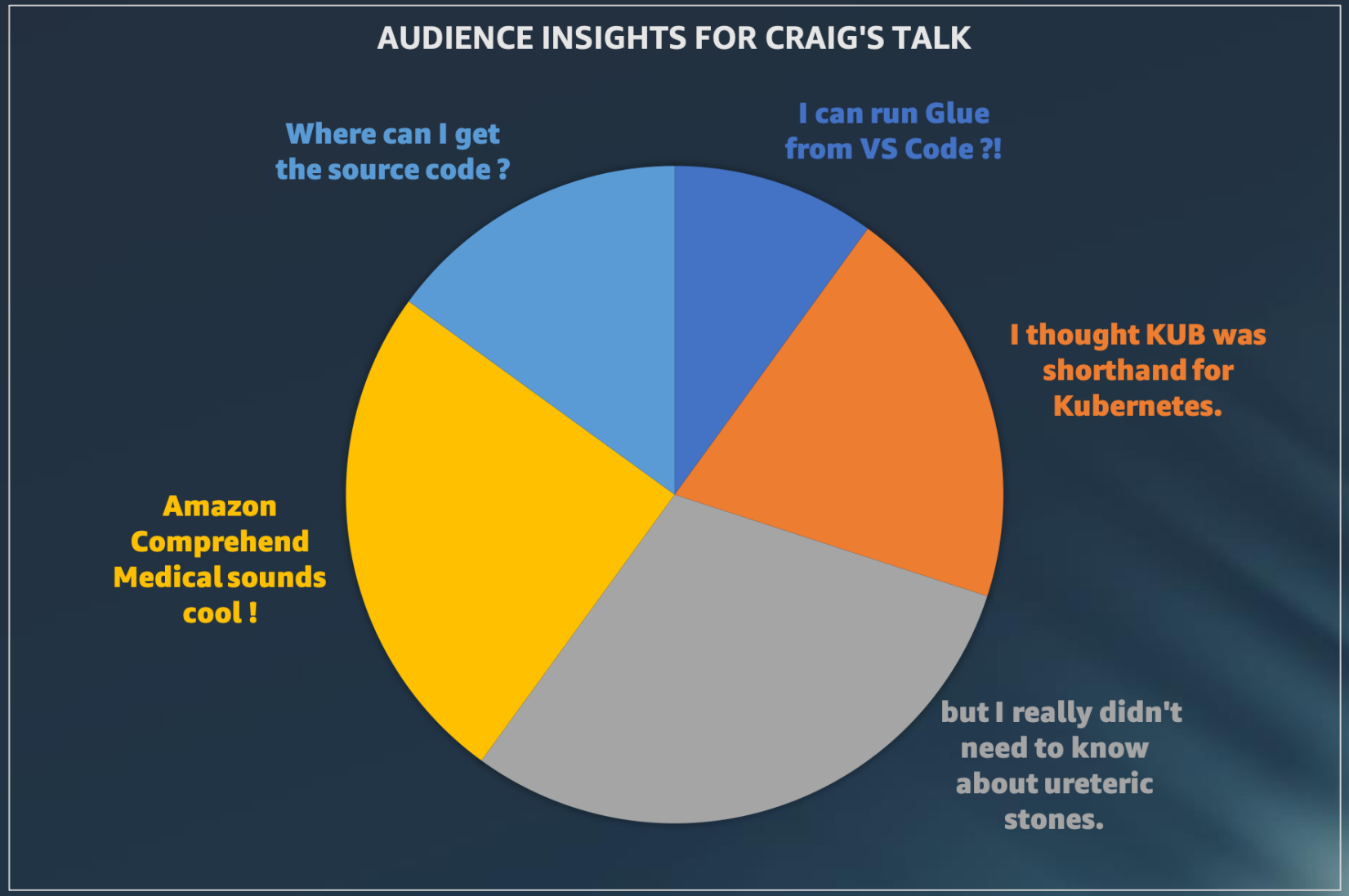
> **Today (name) mentioned needing some detail about nuclear medicine so I went into the dashboard you sent me ... Within seconds I was able to pull out the proportions of various different examinations done in that category and the detail behind these. Otherwise, it would have taken days or weeks of manual queries and adjustments.**

Dr Anthony Doyle

Clinical Leader for Radiology, Hospital and Specialist Services,
Health New Zealand

Demonstration

Recap



Additional resources

- Amazon Comprehend Medical: https://docs.aws.amazon.com/comprehend-medical/latest/dev/comprehendmedical-welcome.html
- AWS Free Tier: https://aws.amazon.com/comprehend/medical/pricing/#Free_Tier
- Amazon Comprehend Medical - GitHub Repositories:
  https://github.com/aws-samples/amazon-comprehend-medical-fhir-integration
  https://github.com/aws-samples/amazon-comprehend-medical-enrich-custom-models
- AI Powered Health Data Masking – AWS Solutions Library: https://aws.amazon.com/solutions/implementations/ai-powered-health-data-masking
- Extract and visualize clinical entities using Amazon Comprehend Medical – Blog: https://aws.amazon.com/blogs/machine-learning/extract-and-visualize-clinical-entities-using-amazon-comprehend-medical/

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