InterSystems
Creative data technology

Medical Device Waveform Data

Too Much and Too Fast

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第44回医療情報学連合大会
（第25回医療情報学会学術大会）
COI開示

演題名：IRIS for Healthを利用した医療デバイスモニタリングの海外事例と国内での取り組み

筆頭演者名：　Qi Li, InterSystems Corporation

　私が発表する今回の演題について開示すべきCOIはありません。

Agenda

- Biomedical use case at MGB
- Technical Challenges
- Platform Solutions
- Test Run in Live Environment
- 日本国内での取り組み

Biomedical use case at MGB

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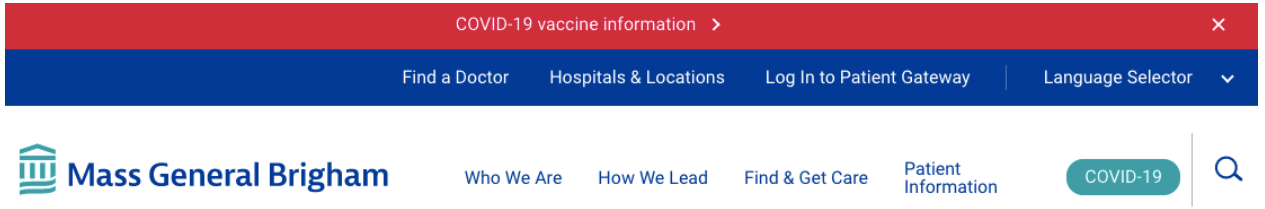
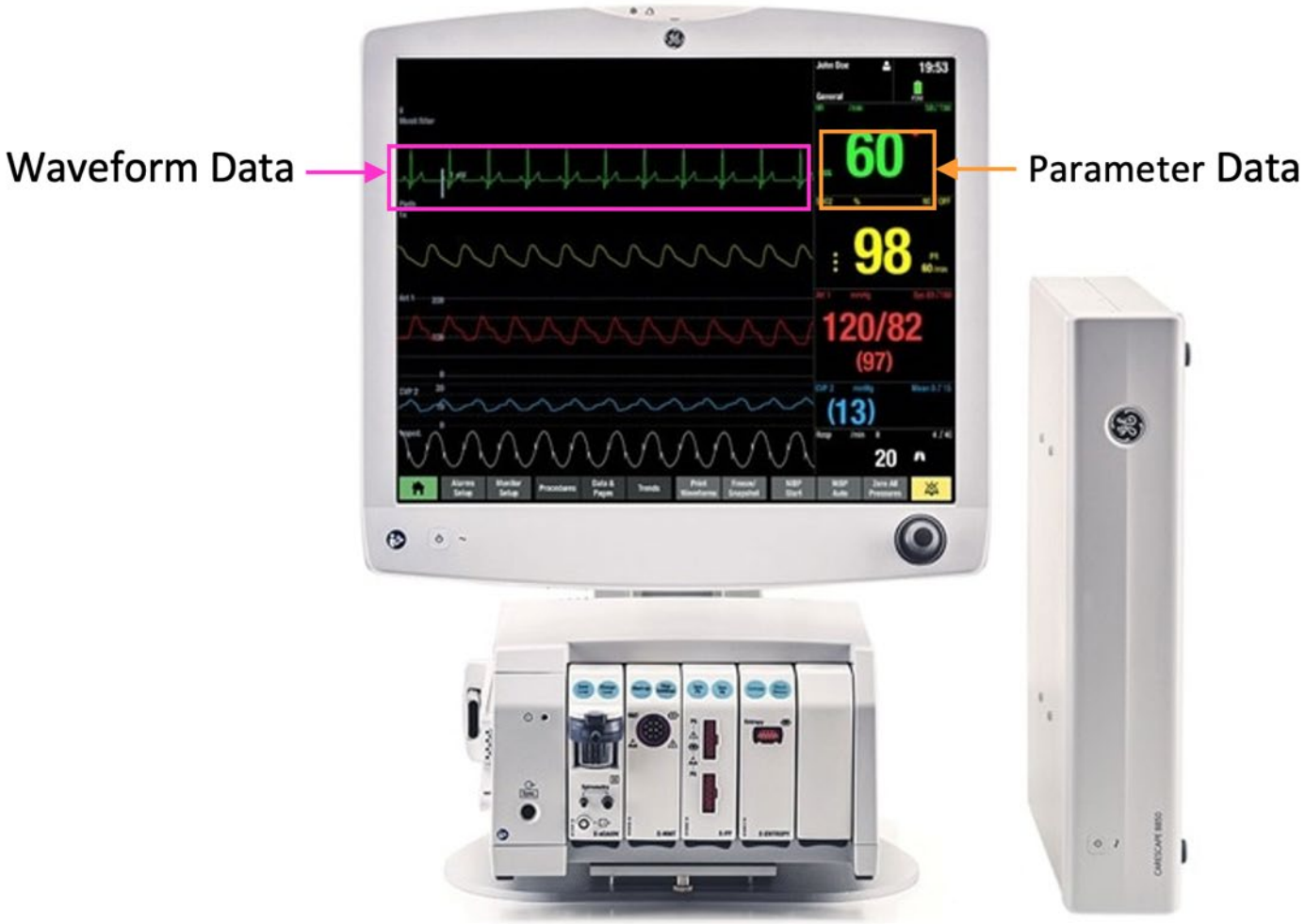
Mass General Brigham (ex- Partners Healthcare)

One of the largest Healthcare Provider in US

- # of employee 80,000
- # of Patients 2.5 million



GE Carescape B850

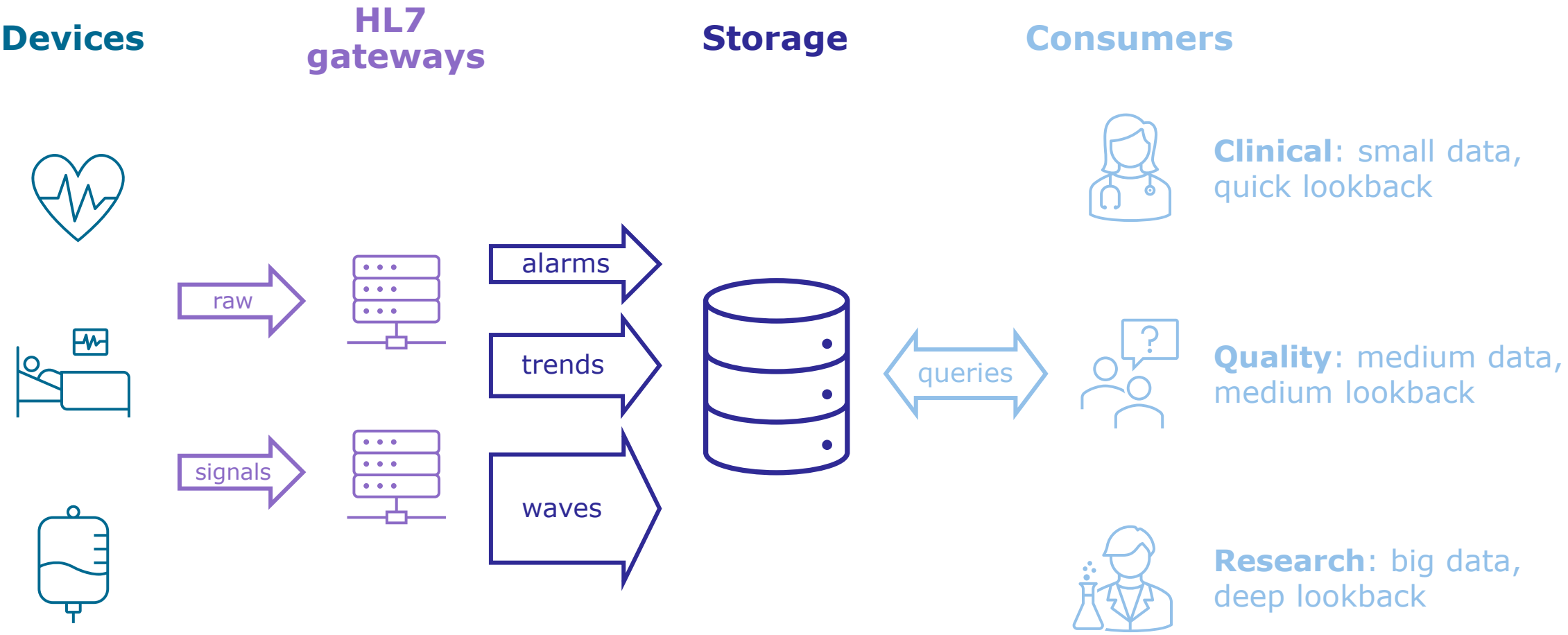


Biomed Use Cases from MGB

- **Research:** Analysis of blood pressure waveforms to predict hemodynamic parameters such as cardiac output, systemic vascular resistance and aortic compliance

- **Clinical:** Display of waveforms on a dashboard that also displays alerts based on EMR data

System Overview



Technical Challenges

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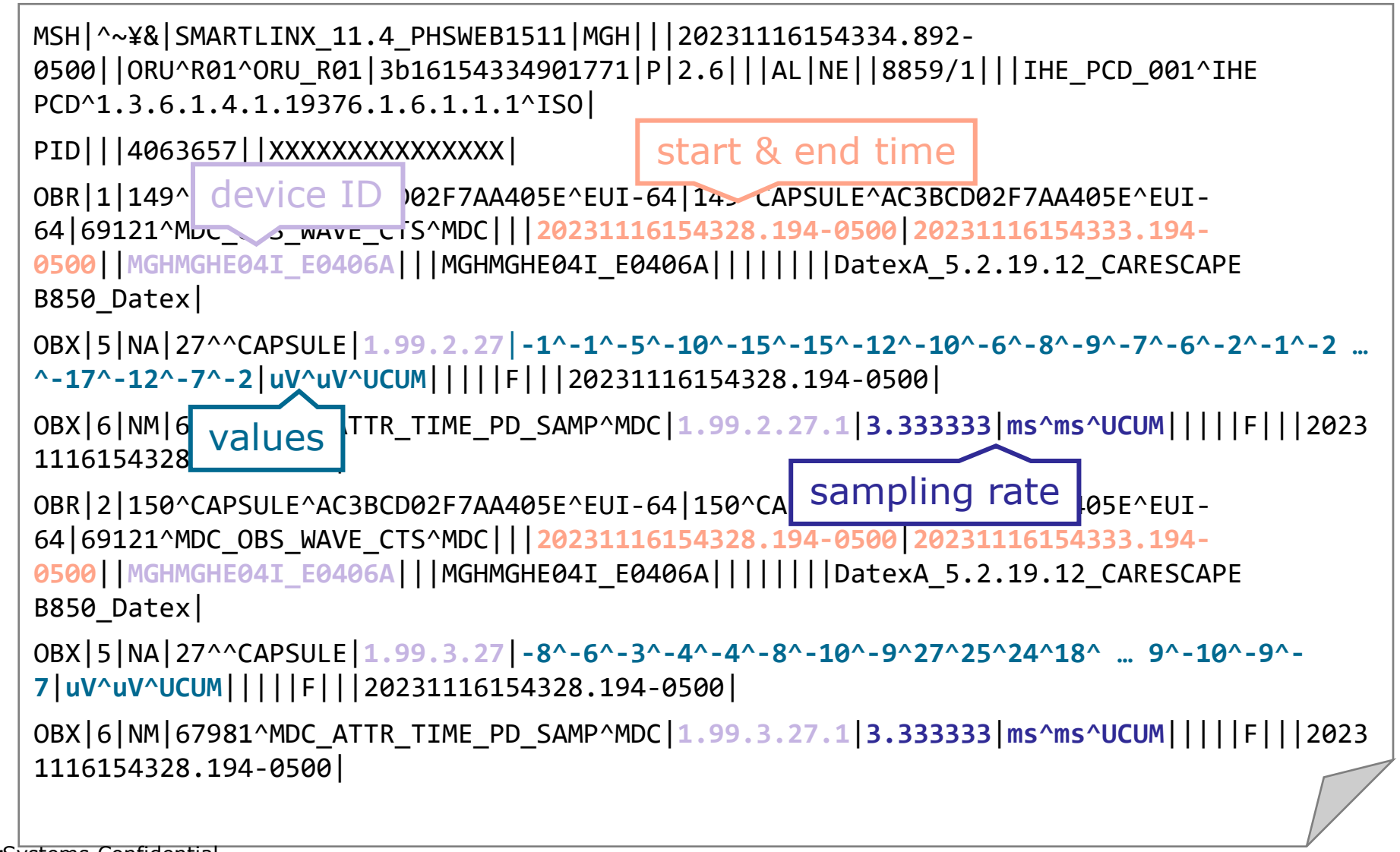
What Are the Actual Messages

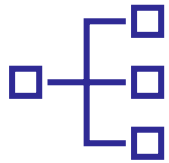


Key Challenges

High-velocity, high-volume ingestion

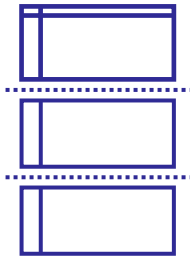
- **Maximize parallelization** to avoid contention points

Variability of device data and metadata



- Support **varying sampling rates** for waveforms, trends and alerts
- **Metadata arrives separately**, often out-of-order with series

Diverse query needs lead to complex storage requirements



- Flexible filter criteria ask for **comprehensive indexing strategy**
- Long retention times for research use case ask for **high-density, tiered storage**

Platform Solutions

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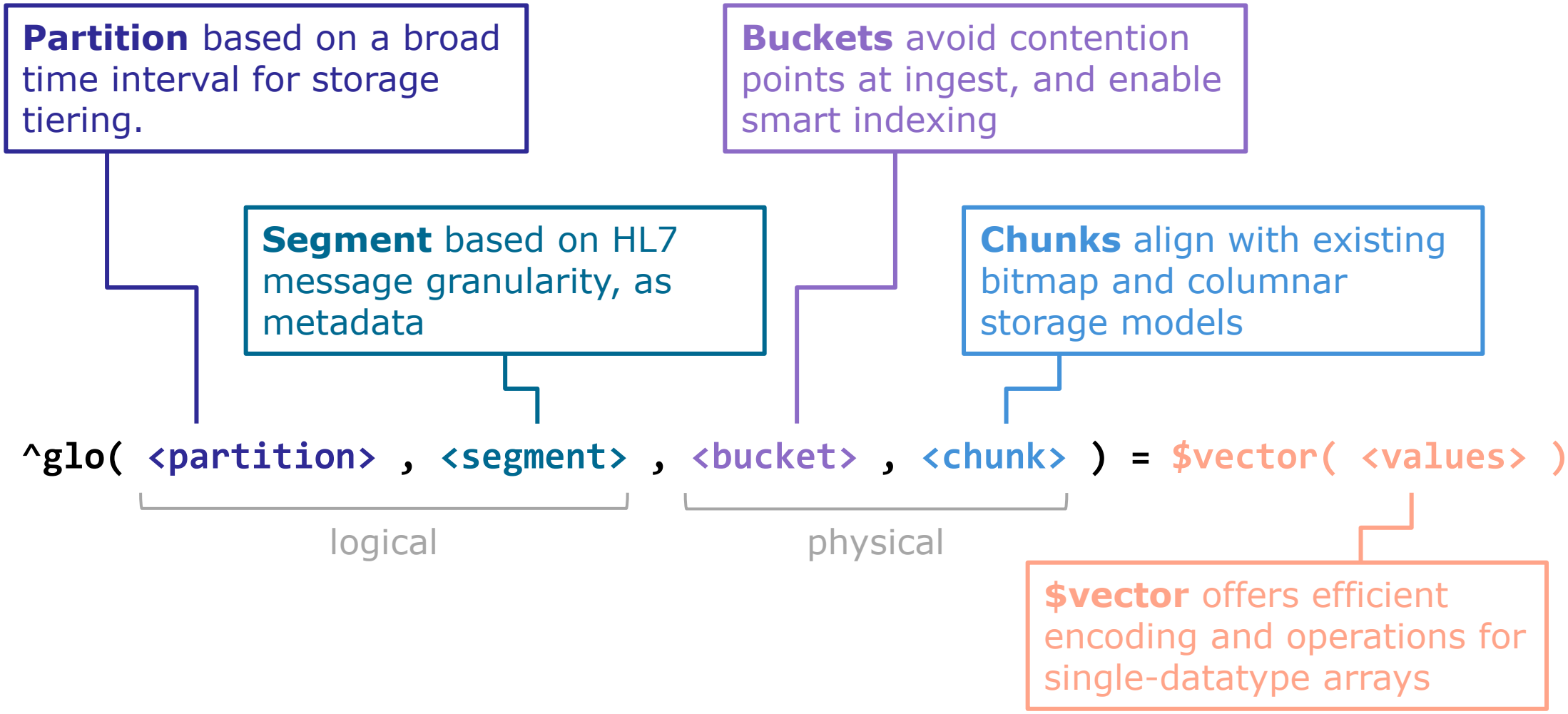
Partitions, Segments, Buckets & Chunks


Partition based on a broad time interval for storage tiering.
Buckets avoid contention points at ingest, and enable smart indexing
Segment based on HL7 message granularity, as metadata
Chunks align with existing bitmap and columnar storage models
^glo(<partition> , , <bucket> , <chunk>) = $vector(<values>)
logical
physical
$vector offers efficient encoding and operations for single-datatype arrays

SQL Projections

Table: MGB_Test.SegmentReading

Field Name	Datatype
ID	%Library.String
bucketID	%Library.Integer
epoch	%Library.Integer
pos	%Library.Integer
segmentBucket	%Library.String
segmentID	%Library.String
ts	%Library.PosixTime
value	%Library.Integer

Table: MGB_Test.DeviceReading

Field Name	Datatype
ID	%Library.String
bucketID	%Library.Integer
deviceID	%Library.String
epoch	%Library.Integer
readingID	%Library.Integer
ts	%Library.PosixTime
value	%Library.Integer

Table: MGB_Test.Meta

Field Name	Datatype
ID1	%Library.BigInt
ID	%Library.String
deviceID	%Library.String
epoch	%Library.Integer
patientID	%Library.String
segmentID	%Library.String
facility	%Library.String
unit	%Library.String
room	%Library.String
bed	%Library.String
deviceType	%Library.String
deviceSubId	%Library.String

SQL Queries - Clinical

"Using clinical viewers for viewing patient vital signs along with alarms in close to real-time settings remotely."

```
SELECT deviceID, deviceType, deviceSubId, ts, value
FROM   MGB_Test.SegmentReading sr
JOIN   MGB_Test.Meta m ON (sr.segmentID = m.segmentID)
WHERE  m.patientID = '0123456789'
       AND sr.ts BETWEEN CURRENT_TIMESTAMP
           AND CAST(CURRENT_TIMESTAMP - 180000000 AS POSIXTIME) -- last 3 minutes
ORDER BY deviceID, ts
```

SQL Queries - Research

"Retrieve all occurrences of arrhythmia alarms for [xyz unit] from the past month, week, or day, along with the corresponding waveforms that occurred immediately before or during each alarm."

```
SELECT arr.bed, arr.ts, arr.value, ecg.deviceID, ecg.ts, ecg.value
FROM (
       SELECT bed,ts,value
       FROM   MGB_Test.SegmentReading sr JOIN MGB_Test.Meta m ON (sr.segmentID = m.segmentID)
       WHERE  m.deviceType = 2601 AND sr.value > 3       -- arrhythmia device id and alarm value
              AND m.unit = 'MGHL10'                      -- specific unit for device
              AND sr.ts >= TO_POSIXTIME('2023-11-01','yyyy-mm-dd')
              AND sr.ts < TO_POSIXTIME('2023-12-01','yyyy-mm-dd')    -- November 2023
     ) arr JOIN (
       SELECT deviceID, bed,ts, value
       FROM   MGB_Test.SegmentReading sr JOIN MGB_Test.Meta m ON (sr.segmentID = m.segmentID)
       WHERE  m.deviceType = 27                          -- ECG device type
     ) ecg ON ecg.bed = arr.bed                          -- ECG and arrhytmia devices on same bed
           AND ecg.ts > CAST(arr.ts - 120000000 AS POSIXTIME)   -- ECG for 2 min before arr alarm
           AND ecg.ts < CAST(arr.ts + 60000000 AS POSIXTIME)    -- and 1 min after
ORDER BY arr.bed, arr.ts, arr.value, ecg.deviceID, ecg.ts
```

Test Run in Live Environment

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All ICU, OR, and Peri-operative Units at MGH

July 31st 2024 (Wednesday), 12 IRIS ports for all 900-1000 devices

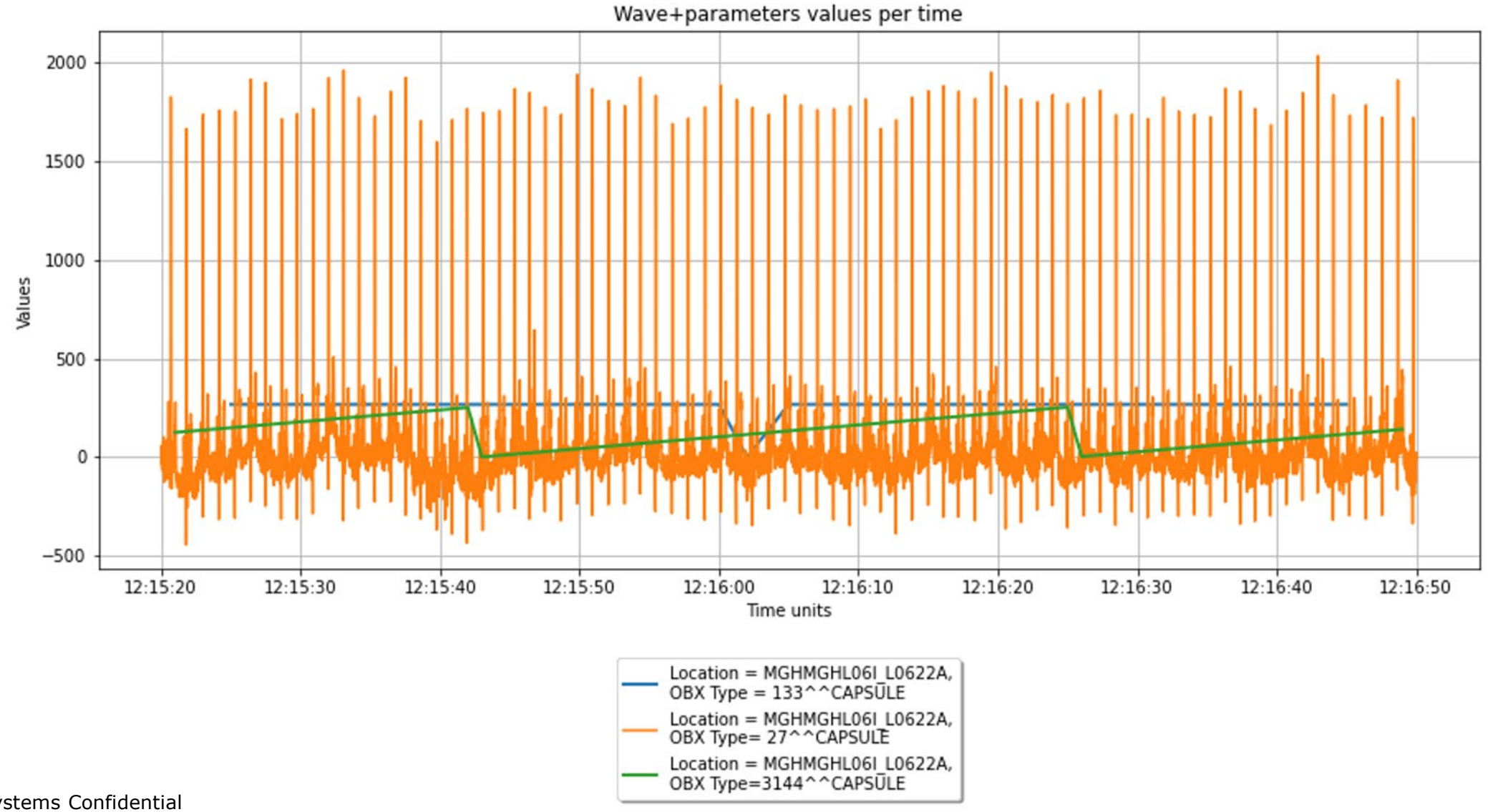
Start	Duration	Total messages	Breakdown	Steady-state
11:12 AM	34.5 min	1,395,399 msgs	96% parameter 4% waveform	710 msgs per second

	MGB Count
Beds	751

Storage Compression

	Message Counts				Stored Size		
Data set	#HL7 messages	By type	#HL7 messages	% of messages	HL7 stored size	IRIS stored size	% HL7 stored size
July 31st	1395399	Waveform	60339	4%	419	2	0.5%
		Parameter	1335060	96%	8100	999	12%

Time Alignment of Waveform and Parameters



Result

Ingestion Rate

High-density storage

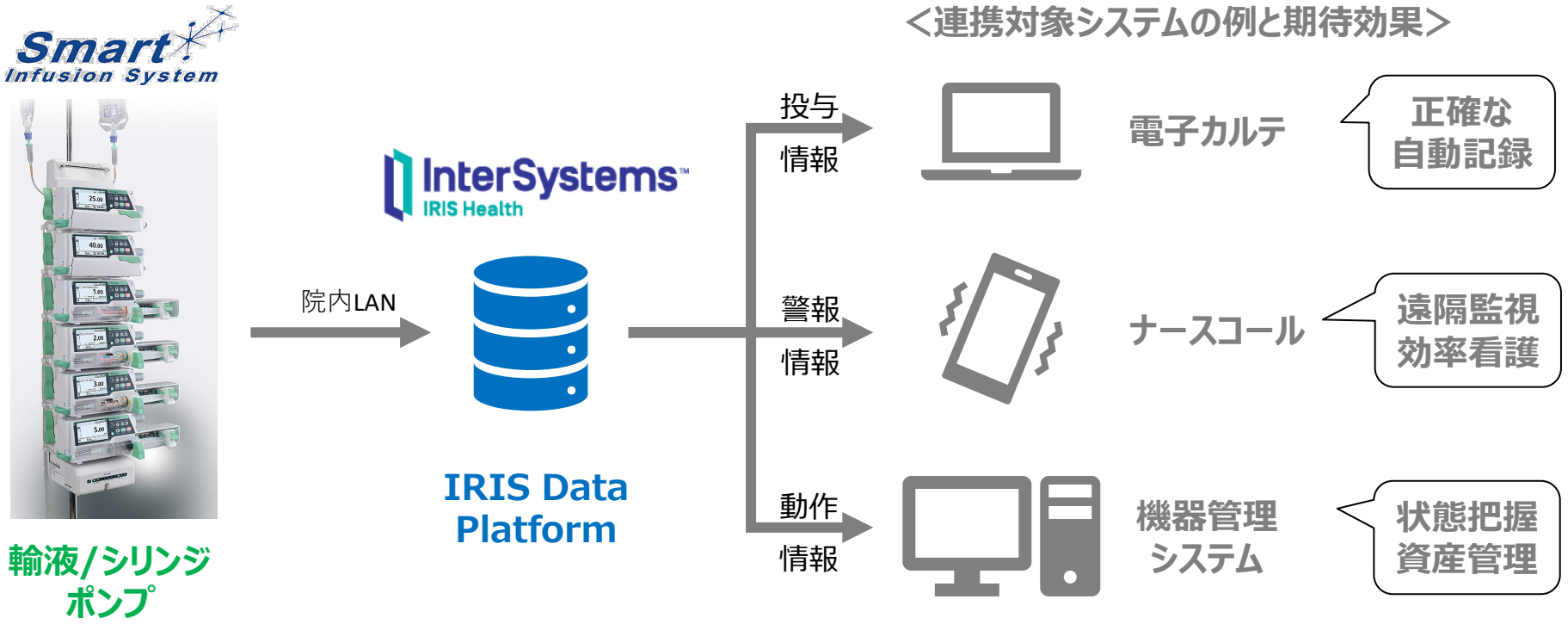
Efficient clinical & research queries

日本国内での取り組み

医療デバイスモニタリングソリューション（参考出品）

InterSystems × TERUMO

輸液/シリンジポンプは院内にある医療機器のうち特に台数の多いものの一つであり、ほぼ全ての部署で使用されています。各部署にはポンプの薬剤投与状況を確認し、記録するという業務がありますが、スタッフは多忙ゆえそれらを遅滞なく、間違いなく行うことが難しい場面もあると聞きます。そこで、インターシステムズジャパンは通信機能を搭載したテルモ社製スマートポンプから、①流量・積算量などの投与情報、②各種アラーム・アラートなどの警報情報、③投与状況など動作情報を、IRIS Data Platformに直接取込する機能を開発中です。これらの情報を他の院内システムに連携することで正確な記録、遠隔監視、資産管理を実現できるため、院内業務のさらなる生産性向上に貢献できると考えます。



情報連携による効果のイメージ
～医療安全、医療従事者の働き方改革をサポート～

病棟によっては数時間おきに点滴の記録をする必要があるが・・・

多忙で入力が後回しになりがち・・・

電子カルテ

- ✓ 流量、積算量が時刻情報とともに自動入力
- ✓ 正確で遅滞ない記録を実現

個室のポンプの警報は聞こえにくい・・・

点滴が終わってナースコールを押されるけど、本当は事前に対応したい

ナースコール

- ✓ セントラルモニタやスマホで「患者さん＋警報内容」を把握
- ✓ 「終了3分前」などの情報により先回り対応も可能に

たくさんあるポンプの稼働状況を管理したいが・・・

機器管理システム

- ✓ ポンプの動作状況を監視
- ✓ 部署別の稼働率や警報傾向の解析、把握も可能

Thank You

Qi Li, MD, MBA

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