OAK RIDGE National Laboratory

HPCM Monitoring Experience @ OLCF

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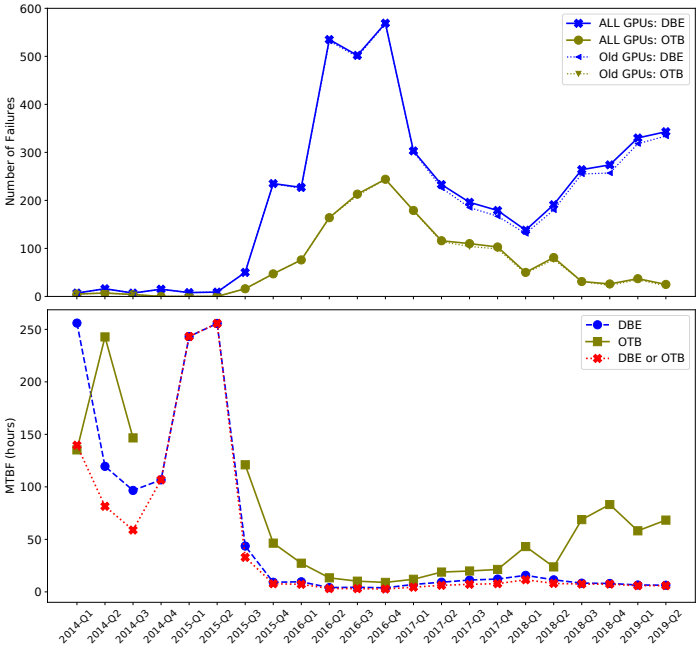
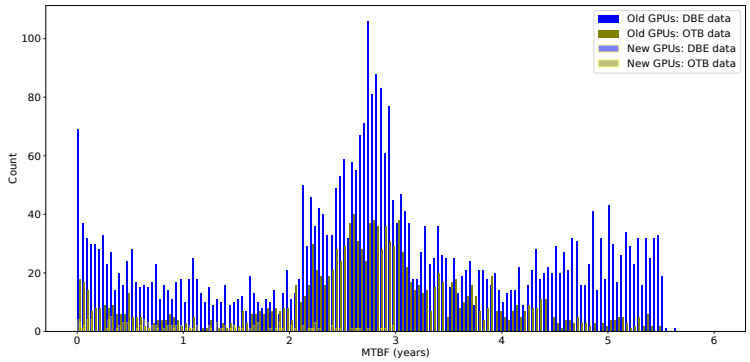
U.S. DEPARTMENT OF ENERGY

2014: Reliability of Titan is Focused on MTBF

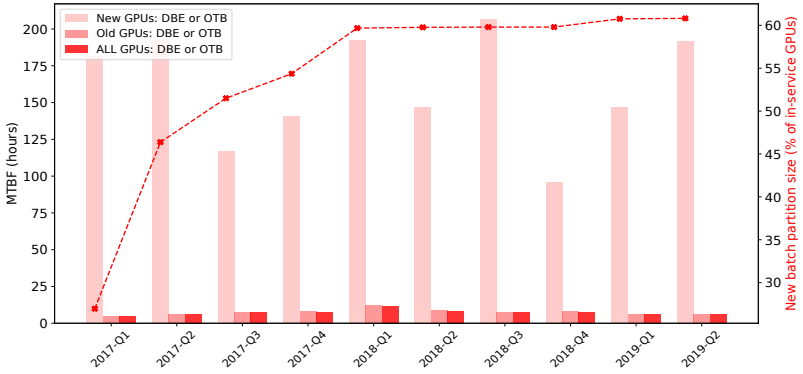
In 2015, we started seeing large numbers of GPU failures



System-wide Reliability: Quarterly number of failures (top) and MTBF (bottom).



Individual GPU Reliability: MTBF histogram for units that had at least one failure. Interpret carefully: lacks information from units with no failures!



Old–New as Two Partitions: MTBF differs by 12x factor!

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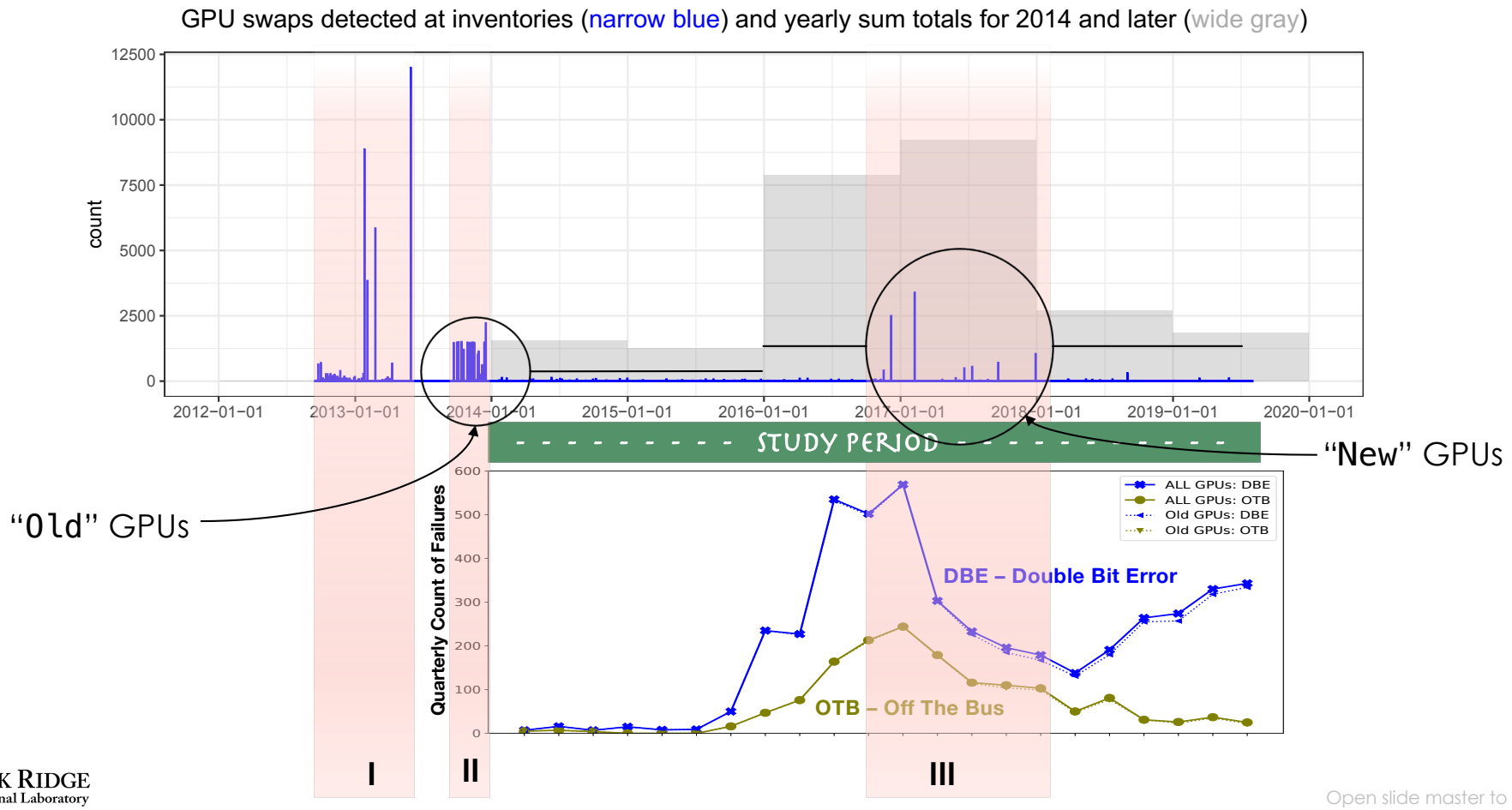
Ostrouchov, George & Maxwell, Don & Ashraf, Rizwan & Engelmann, Christian & Shankar, Mallikarjun & Rogers, Jim. (2020). GPU Lifetimes on Titan Supercomputer: Survival Analysis and Reliability. 1-14. 10.1109/SC41405.2020.00045.

Three Rework Cycles and Years of Stable Operation



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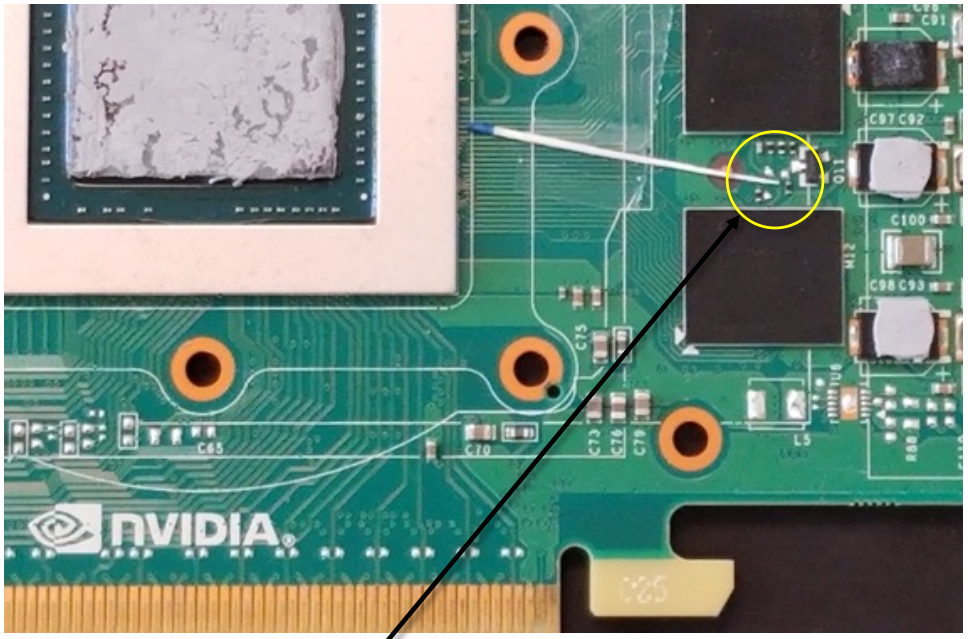
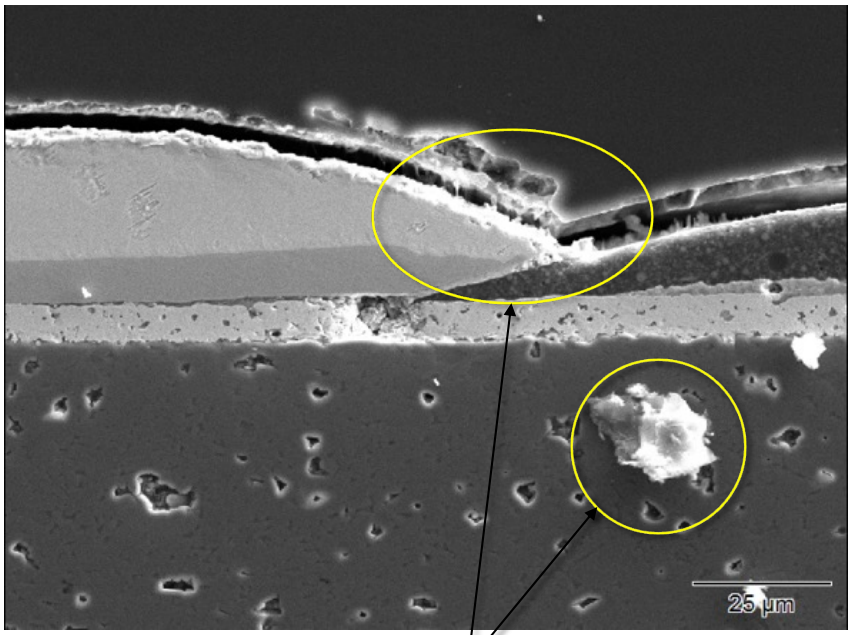
Root Cause: Non-ASR Components on SXM GPU



NVIDIA SXM – Location of a non-ASR



Silver-sulfide corrosion
"Flowers-of-Sulfur"

ASR = Anti-Sulfur Resistor

We had logs of hardware swaps and failures, but without well-established analytics tools it took us **much** longer than we would have liked to diagnose and fix these issues

Data Platform Motivations

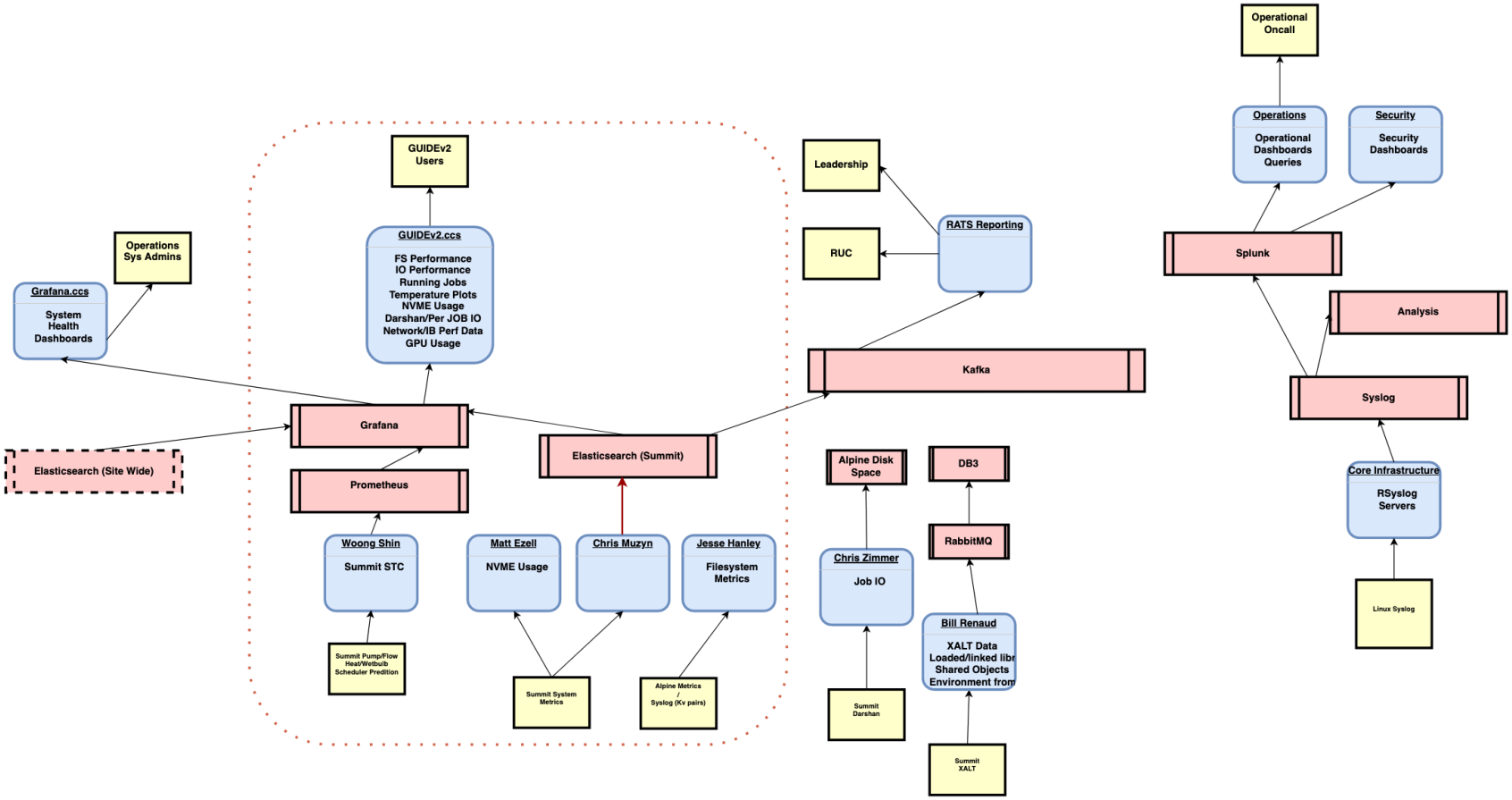
'Scaling' was no longer scaling

- Increased system complexity and changes to both systems and schemas over time made data analytics incredibly manual
- We needed to replace batch processing and enable stream processing where possible
- Traditional data sinks did not provide flexibility of modern data warehouses for applications users wanted to use
- A central data bus was necessary to decouple opaque data pipeline sources and sinks and provide O(n) scaling

New technologies made this possible

- Several scalable, robust, flexible message busses were becoming mature
- Modern data warehouse designs and search/analytics tools like Elastic were being explored by various teams
- Data analytics tools were maturing and our operations teams were becoming more capable of slicing and dicing telemetry streams
- Platform as a service (PaaS) had just been deployed within NCCS and was reducing administrative burden

2019: NCCS Analytics and Monitoring 'Platform'



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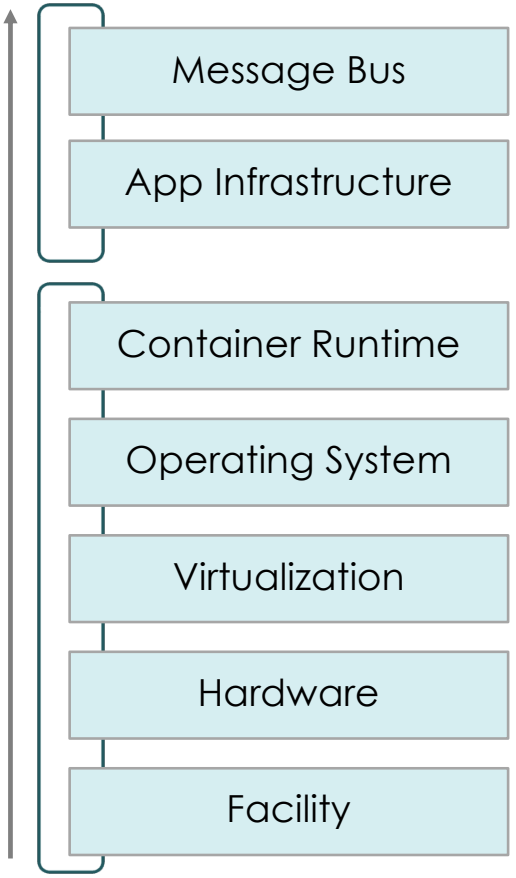
Data Platform Strategy – We needed a new capability

What is the scope for this new capability?

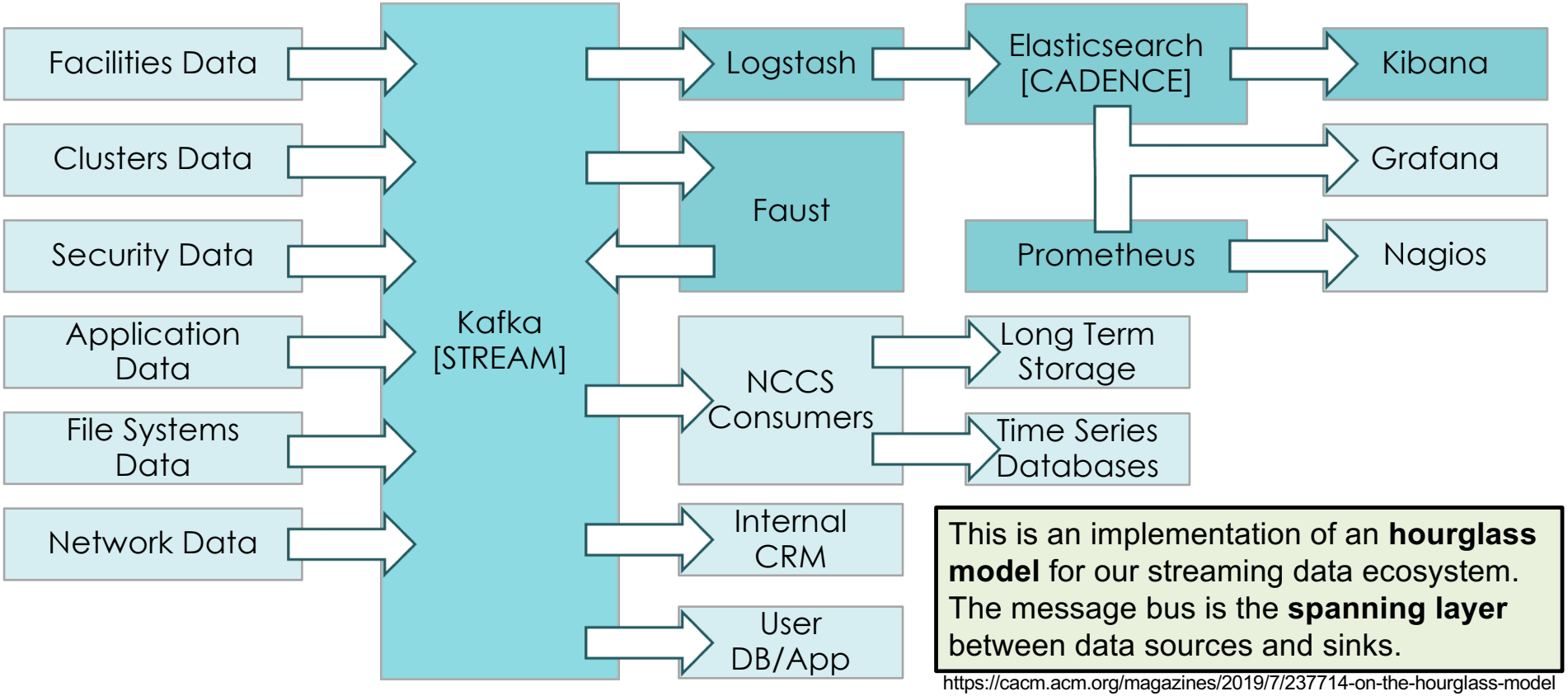
- Use operational / SRE best practices to provide data assurance
- Reduce the 'data wrangling' that scientific end users have to do
- Be advocates for both data producers and consumers
- Inform institutional data policy and help resolve data ownership conflicts

What is the application stack?

- Deliberately focus on 'top of stack' to support applications, platform users, and data analysis
- Utilize PaaS for supporting layers to minimize complexity
- Cleanly and clearly define data pipeline roles and responsibilities between consumers and producers



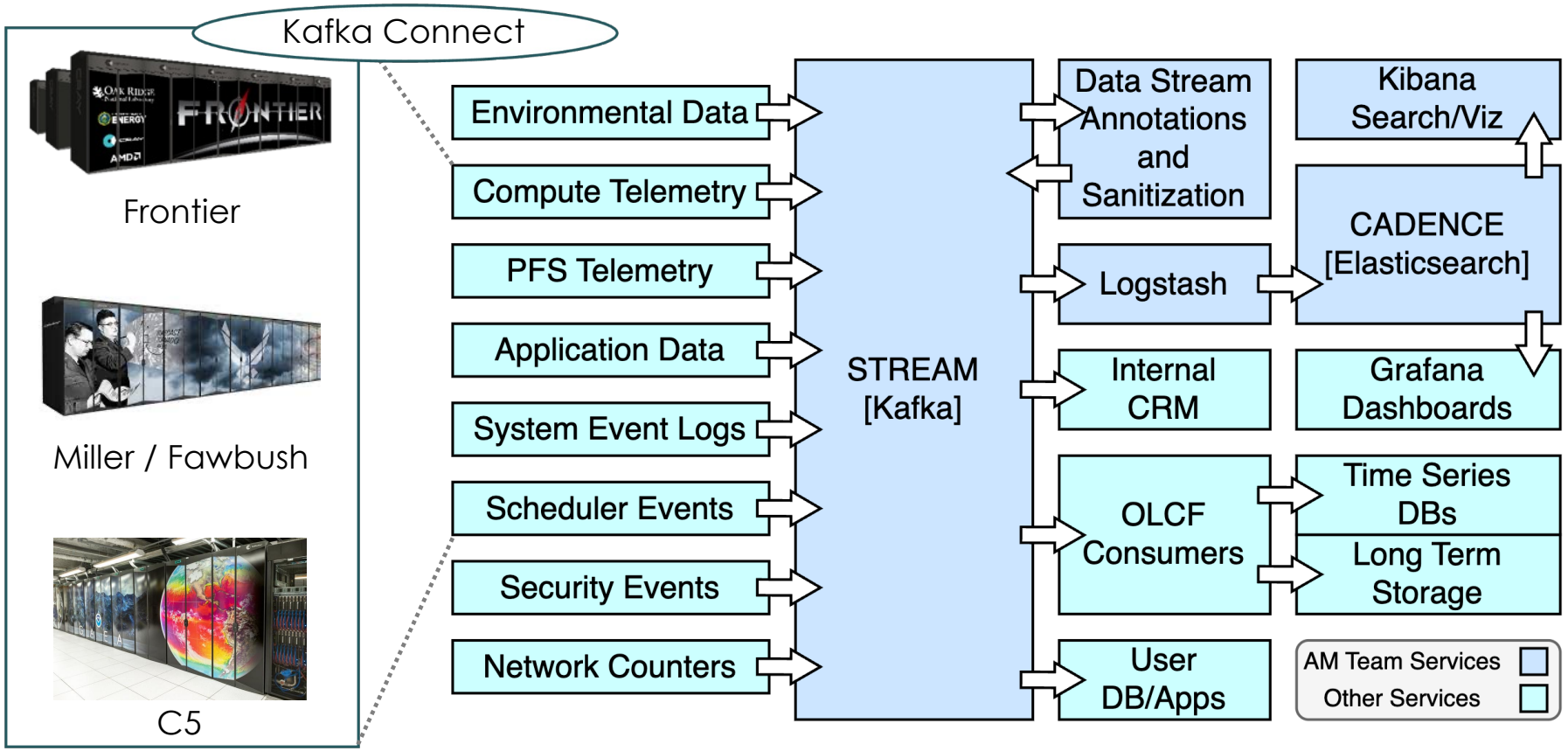
2021: NCCS Analytics and Monitoring Platform



This is an implementation of an **hourglass model** for our streaming data ecosystem. The message bus is the **spanning layer** between data sources and sinks.

https://cacm.acm.org/magazines/2019/7/237714-on-the-hourglass-model

STREAM Architecture in 2023



Data Platform Challenges

Sustainability

- Data sources ***will change*** over time
- Systems will come and go and technology will change
- Technical debt can be difficult to reduce once accrued
- Once automation exists for production and consumption… good luck!

Documentation

- Data producers should, ***in theory***, be the best equipped to answer questions about data sources
- Data consumers typically ***don't have enough context*** to understand the information they receive through telemetry pipelines

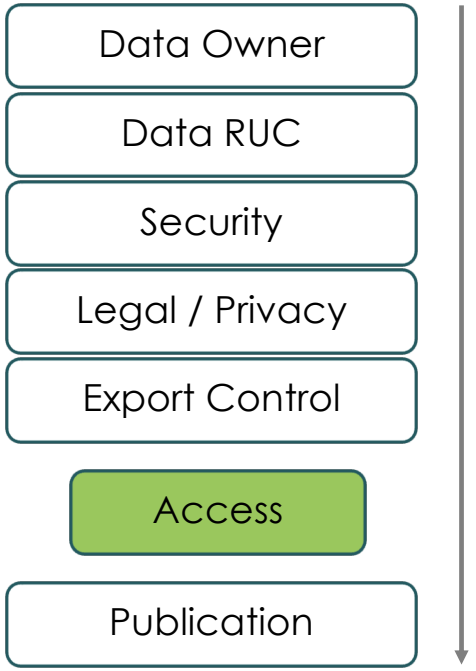
Performance / Robustness

- Controlling types and sizes of data can be challenging – ***data throughput tends to grow over time***
- Monitoring individual topics can be difficult, especially when ***a few key topics dominate*** systems engineer time

Lessons Learned – Access Control

Controlling Access

- We define a data 'owner' to be the producer of data, and we give some control over who can access streaming messages.
- Data 'consumers' apply for access and are granted individual topic credentials based on need.
- The OLCF has an interest in reviewing potential research outcomes and discoveries
  - Misinterpretation of information is quite common!



Lessons Learned – Topic Naming

Topic Naming

- Changes to topic names as well as changes to client configuration is very difficult to manage
- We developed a sustainable topic naming scheme based on use cases
- NCCS uses a delimited topic name 'tuple' based on data source owner, system name, the subsystem that produces messages, and the specific topic subject the topic is about
- Example:

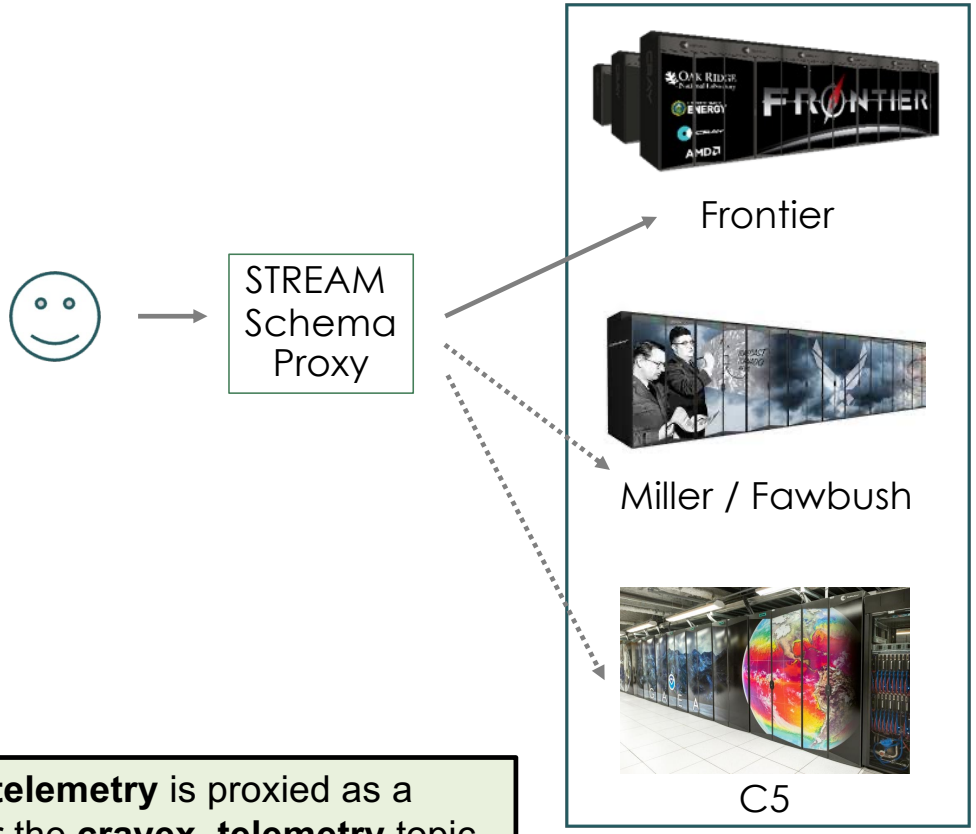
stf002hpc.frontier.hpcm.crayex_telemetry

Source System	Subsystem	Topic Subject
frontier	hpcm	HPCMLOG
c5		SYSLOG
t5		crayex_alerts
miller		crayex_telemetry
fawbush		event_cooldev
ace		hpcm_inventory
		hpcm_inventory_dimm
		log_iml
		powerservice_operations
		powerservice_rawpower
		sensors_node
		slurm_jobs
		…

Lessons Learned – Schema Registries

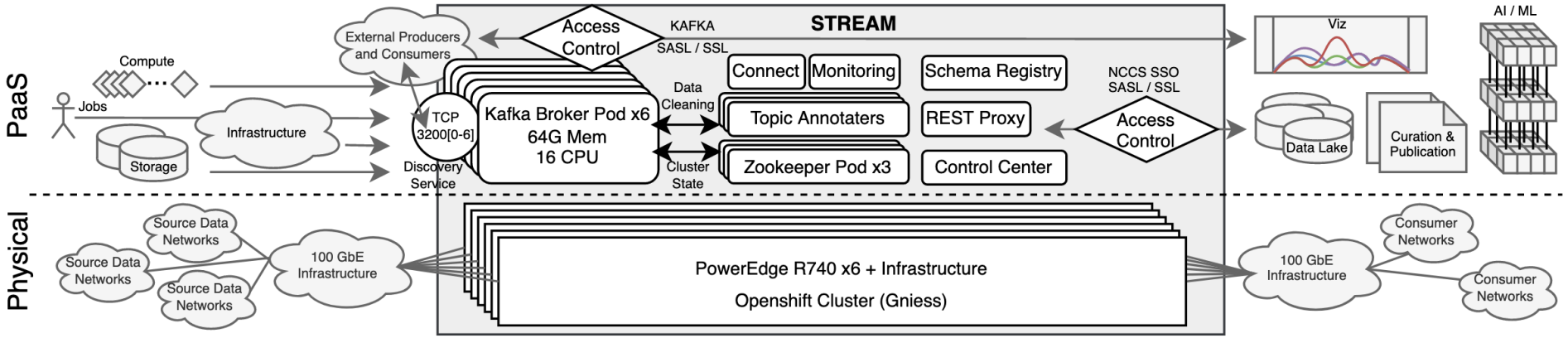
There are many, many registries!

- HPCM Kafka schema registries on various systems may not be configured in the same way
  - The ordering of topics and versioning of topics over time lead to different schema definitions for the 'same topic' across systems
- OLCF developed a fairly simple flask application to 'proxy' schema registry access
  - On client access to STREAM, schema registry request is modified to connect to HPCM schema registry of the system the topic is produced from



A user request for **stf002.frontier.hpcm.crayex_telemetry** is proxied as a request to the Frontier schema registry service for the **crayex_telemetry** topic.

Lessons Learned – Monitoring and Break/Fix



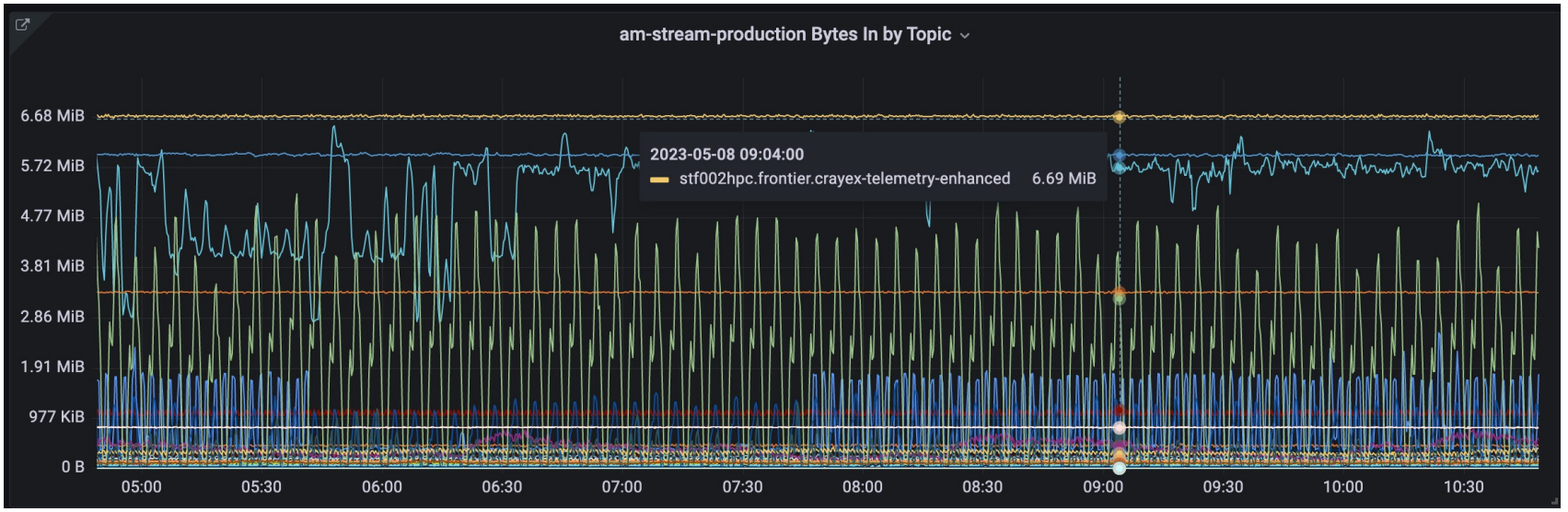
There are many layers of support: from HPE engineers to systems admins to end user applications. Lots of arrows here mean lots of opportunity for breakage! We **monitor the monitoring tools** as best as we can and integrate alerting with existing systems. Buffering at each layer can help preserve data while troubleshooting occurs.

Characterization of crayex_telemetry on several systems

Topic name	Status	Partitions	Production (last 5 mins)	Consumption (last 5 mins)	Followers	Observers	Last produced
stf002hpc.ace.hpcm.crayex_telemetry	Healthy --	1	27.95KB/s	98B/s	3	0	May 8 2023, 11:1
stf002hpc.c5.hpcm.crayex_telemetry	Healthy --	7	1.05MB/s	786.03KB/s	21	0	May 8 2023, 11:1
stf002hpc.fawbush.hpcm.crayex_telemetr	Healthy --	7	434.49KB/s	443.88KB/s	21	0	May 8 2023, 11:1
stf002hpc.frontier.hpcm.crayex_telemetry	Healthy --	40	5.95MB/s	6.75MB/s	120	0	May 8 2023, 11:1
stf002hpc.miller.hpcm.crayex_telemetry	Healthy --	1	169.29KB/s	147.76KB/s	3	0	May 8 2023, 11:1
stf002hpc.t5.hpcm.crayex_telemetry	Healthy --	7	19.03KB/s	19.03KB/s	21	0	May 8 2023, 11:1

Corresponding topics for **crayex_telemetry** from Ace, C5, Fawbush, Frontier, Miller, and T5. Note the differences in partition count, production, consumption, and followers.

Selected Examples of Interesting Behavior



Typical 6-hour window of ‘steady state’ streaming telemetry performance. Most of STREAM’s 223 topics are < 1MiB/s and are dominated by several large topics.

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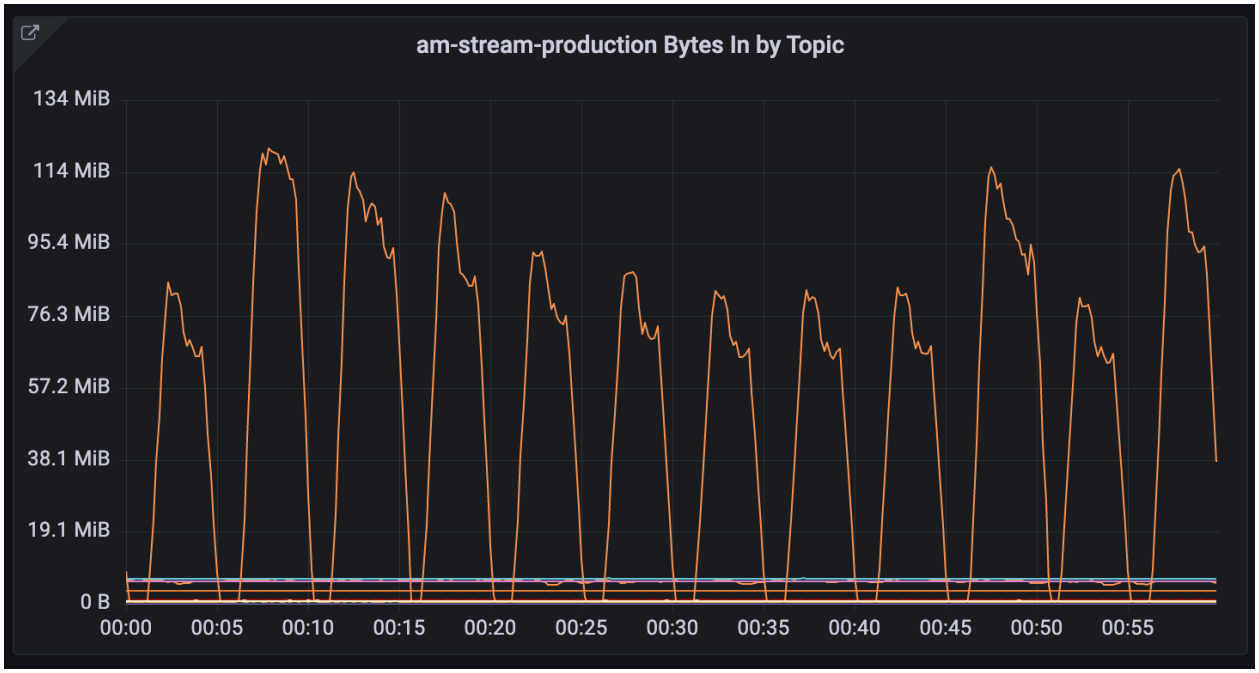
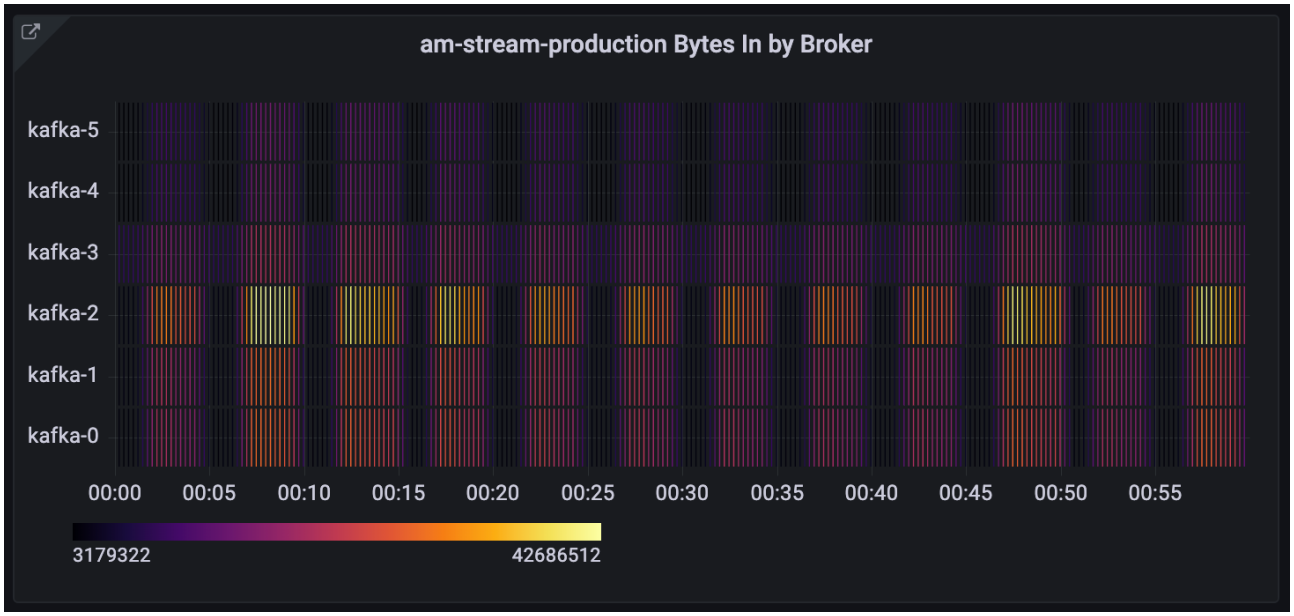


A 1 hour window showing 5-minute collection periodicity of Lustre trace data for Orion.

Selected Examples of Interesting Behavior



Monitoring bytes in per broker with a heatmap diagram reveals periodicity as well as an unbalanced amount of information flowing to the kafka-2 broker for this time interval.

Discussion

Acknowledgements:
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