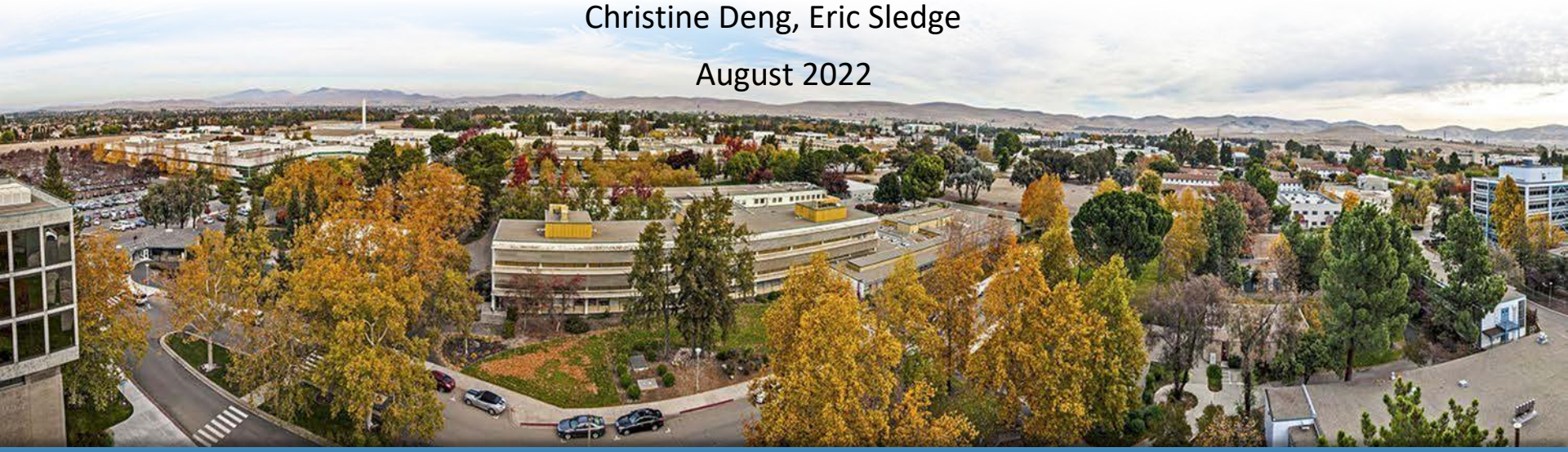
Installation of Flux

2022 HPC Academy Project

Christine Deng, Eric Sledge

August 2022



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The Flux Project Interns

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Claflin University Orangeburg, SC

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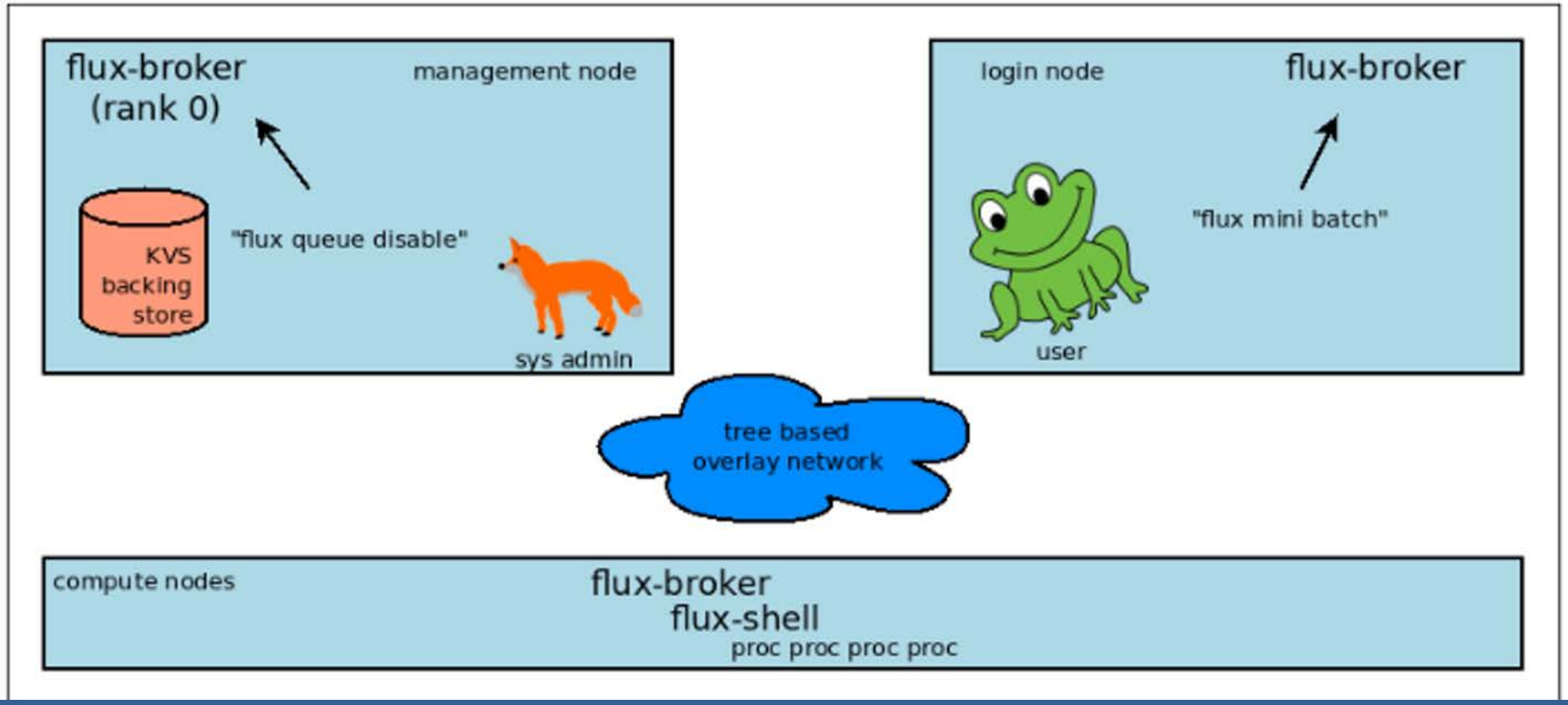
What is Flux?

- Resource management framework
  - Job scheduling algorithm
  - Allocation policy
- Designed for better throughput, job coordination/communication, portability

What is Flux?



https://flux-framework.readthedocs.io/en/latest/adminguide.html

Project Objective

- Install Flux on our cluster
  - flux-core, flux-security, flux-sched
- Run MPI jobs

Running jobs

```c
#include <mpi.h>
#include <stdio.h>

int main(int argc, char** argv) {
    // Initialize the MPI environment
    MPI_Init(NULL, NULL);

    // Get the number of processes
    int world_size;
    MPI_Comm_size(MPI_COMM_WORLD, &world_size);

    // Get the rank of the process
    int world_rank;
    MPI_Comm_rank(MPI_COMM_WORLD, &world_rank);

    // Get the name of the processor
    char processor_name[MPI_MAX_PROCESSOR_NAME];
    int name_len;
    MPI_Get_processor_name(processor_name, &name_len);

    // Print off a hello world message
    printf("Hello world from processor %s, rank %d"
           " out of %d processors\n",
           processor_name, world_rank, world_size);

    // Finalize the MPI environment.
    MPI_Finalize();
}
```

```
[flux@siliconi ~]$ flux mini run -n4 -N4 hostname
siliconi
silicon4
silicon3
silicon2
```

```
[flux@siliconi ~]$ cat flux-run-hello.sh
#!/bin/bash

export OMPI_MCA_btl="tcp,self"
flux mini run -n 4 /var/flux/hello 2>/dev/null | grep -v Unable
```

```
[flux@siliconi ~]$ flux mini batch -n4 -N4 flux-run-hello.sh
ƒ3B23bEkdKM
[flux@siliconi ~]$ flux jobs
       JOBID USER     NAME       ST NTASKS NNODES  RUNTIME NODELIST
 ƒ3B23bEkdKM flux     flux-run-h  R      4      4   2.811s silicon[2-5]
[flux@siliconi ~]$ cat flux-ƒ3B23bEkdKM.out
Hello world from processor silicon2, rank 0 out of 4 processors
Hello world from processor silicon4, rank 2 out of 4 processors
Hello world from processor silicon3, rank 1 out of 4 processors
Hello world from processor silicon5, rank 3 out of 4 processors
```

Challenges

- Limited Web Resources and Documentation
  - Trial and error, and digging around a lot
- Precise Command Line Usage
  - Expert-Friendly, tough if you are used to GUI's, once you know certain commands it gets easier
- Minor edits to configuration files
- Enabling Certain Repos

Future Work and High End Goals

- Explore using the flux API to manage jobs
- Setup the exclude for the mgmt node - normally we would not run real end-user work on the mgmt node
- Investigate the Prolog/epilog

Tools Used

References

https://flux-framework.readthedocs.io/en/latest/adminguide.html
https://flux-framework.readthedocs.io/projects/flux-rfc/en/latest/spec_18.html#language
https://computing.llnl.gov/projects/flux-building-framework-resource-management
https://sc18.supercomputing.org/proceedings/workshops/workshop_files/ws_works115s2-file1.pdf
https://flux-framework.readthedocs.io/en/latest/quickstart.html#spack-recommended-for-curious-users

Questions?

Installing & Configuring Lustre on KVMs

Naomi Cheeves, Gabe Maxfield

August 2, 2022

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Team Members

- Naomi
  - Senior at University of California, Davis
  - Computer Science
  - Graduating December 2022

- Gabe Maxfield
  - Sophomore at Brigham Young University
  - Computer Science
  - Graduating 2025

Goals

Our mission was to find a scalable filesystem for our HPC environment.

We decided to create a small, proof of concept cluster on some kernel-based virtual machines.

Our goals were as follows:

- Investigate Lustre
- Create a miniature lustre cluster utilizing three kvms
- Investigate and install a backend filesystem for lustre (zfs vs ldiskfs).
- Run some benchmark tests

Lustre

- Why use Lustre in HPC?

  Lustre has…

  — Exascale Capacities
    - Lustre uses distributed, object-based storage managed by servers.
      - Very large files can be distributed amongst different data objects and amongst several servers.

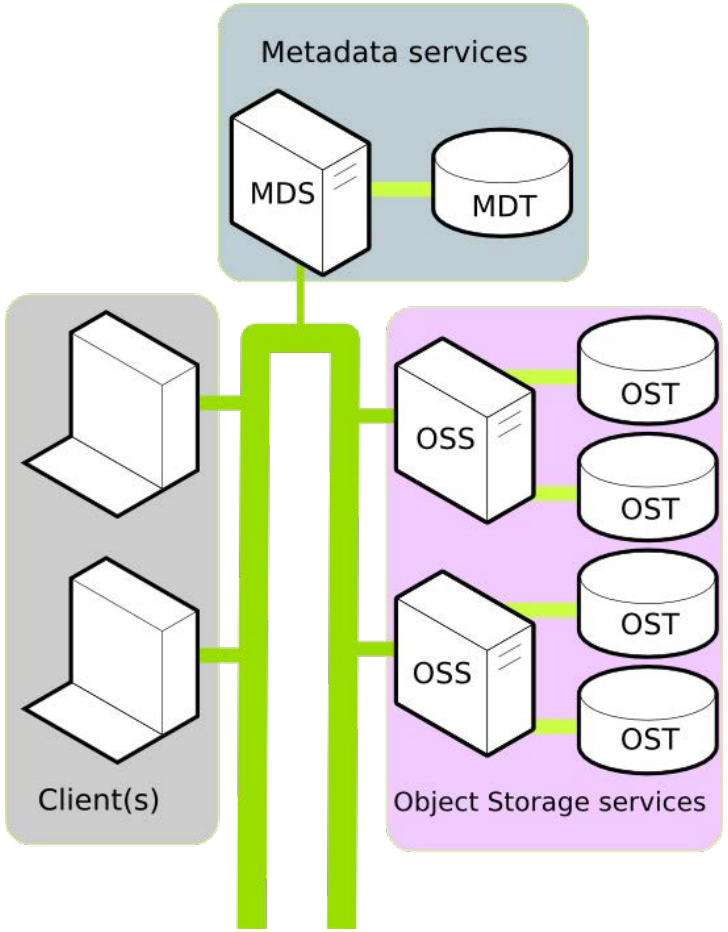
  — Data Integrity (only ZFS)
    - Data is written frequently in the event of a node crashing

  — Massive Scalability
    - Object Storage is low cost and efficient
    - I/O thoroughput and capacity are easily scaled by dynamically adding servers

  — POSIX-compliant on a Linux-based OS

The Lustre Architecture

- Components of a Cluster
  - MGS: Management Server, stores configuration information.
  - MDS: Metadata Server, manages MDTs.
  - MDT: Metadata target that stores file information/ location.
  - OSS: Object Storage Server, manages OSTs.
  - OST: Object Storage Target, storage device, hosts files.
  - Client(s): Access and use the data.



Why ZFS over LDISKFS?

- Larger Capacities
- Integrated Data Integrity

Feature	LDISKFS	ZFS
Max Volume Size	32PB	512PB
Maximum Lustre File Size	512PB	8EB
Native Data Protection	None	Mirror, RAIDZ{1,2,3}, DRAID (Future)
Detect/ repair silent data corruption	None	Yes
File system repair	Offline: FSCK	Online: ZFS Scrub

What we accomplished

In the end, our setup consisted of:

- 3 Centos 7 Kernel-based virtual machines
- A single MGS/MDS/MDT and OSS/OST setup with one client
- A small Lustre cluster built from source utilizing a ZFS backend filesystem

- What was not accomplished:

- Benchmark tests
  - Lustre utilizing local storage
  - Lustre utilizing JBODs

Challenges

- Outdated resources
  - Tutorials written for an older RHEL version
  - More niche technology with few public discussions
  - Poor documentation (Except Lustre manual)
    - Documentation used old methods and syntax
- Installing Lustre
  - Lustre packages hard to find/ Don’t support ZFS
  - Setting up the development environment
    - LNET
    - Mounting Lustre Devices

Possible Future Goals

- High Availability
  - Utilize pacemaker to maintain high availability in the event of server failure
- Explore Hierarchical Storage Management (HSM)
  - Integrate Cheap Long-term Storage Solutions
  - Automatically move old data to/ from a cheaper/ slower storage medium
  - Invisible to end client
- Explore Clustered Trivial Database (CTDB)
  - Interface for the Server Message Block protocol (Windows protocol)
  - Extend filesystem support for different clients and operating systems

Sources

- https://wiki.lustre.org/
- https://wiki.whamcloud.com/
- https://en.wikipedia.org/wiki/Lustre_(file_system)
- https://wiki.lustre.org/images/6/64/LustreArchitecture-v4.pdf
- https://www.netapp.com/data-storage/storagegrid/what-is-object-storage/

RabbitMQ and Kafka

Prabhleen Bagri and Lindsey Amaro
Mentor: David Fox

August 11, 2022

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Team Members

- Prabhleen Bagri
- San Jose State University
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- Expected Grad: May 2023

- Lindsey Amaro
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- Mathematics
- Expected Grad: June 2024

What is a Message Broker?

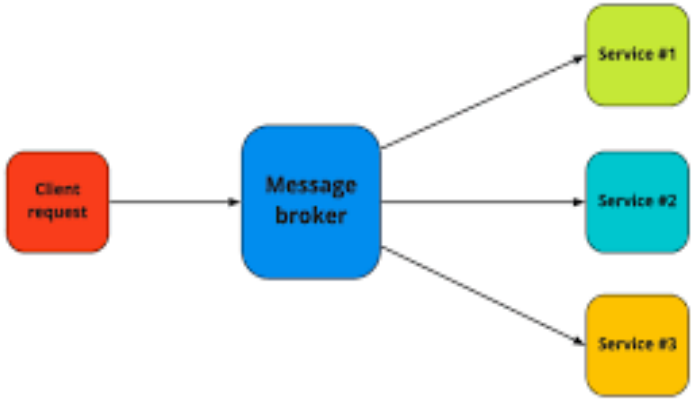


Diagram source: https://tsh.io/blog/message-broker/

Normally we would use TCP to send messages, but there are drawbacks

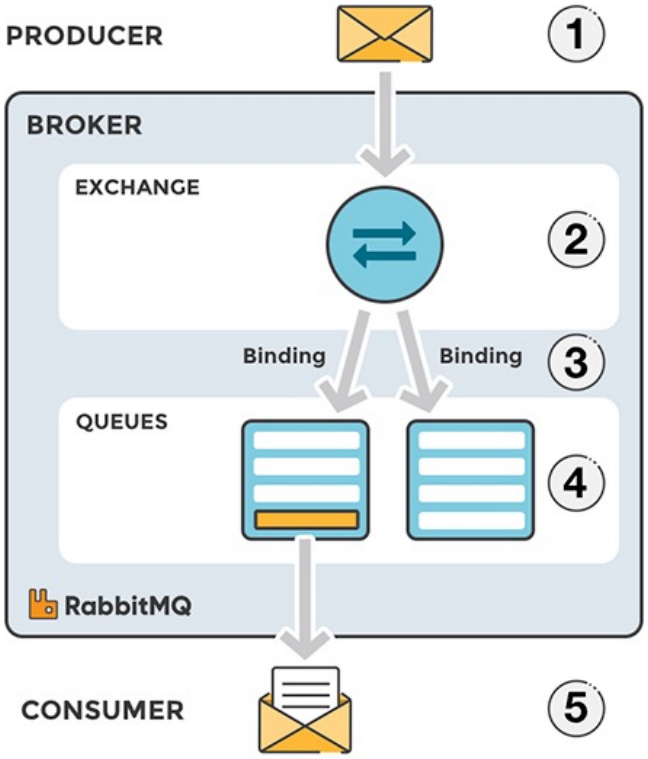
→ **SOLUTION : message brokers**

Message brokers sit in between two services that interact. They enable applications and systems to communicate with each other and exchange information.

- Acts as a buffer i.e. it holds messages until it is ready to be received
- Allows sender to issue message without knowing where receiver is
- Improved system performance because it allows asynchronous processing
- facilitates decoupling

RabbitMQ

- Message Broker
- Producer sends messages to exchanges, which then route those messages to queues that consumers can access
- Several Types of Exchanges support different routing patterns:
  - Direct
  - Fanout
  - Topic
- Messages deleted from queues once consumed
- Use Cases:
  - Situations that require complex sending patterns
  - Instances where quick message response is important
  - Applications that need to work with messaging protocols such as AMQP
- Companies that use RabbitMQ
  - T-Mobile
  - Reddit
  - Trivago



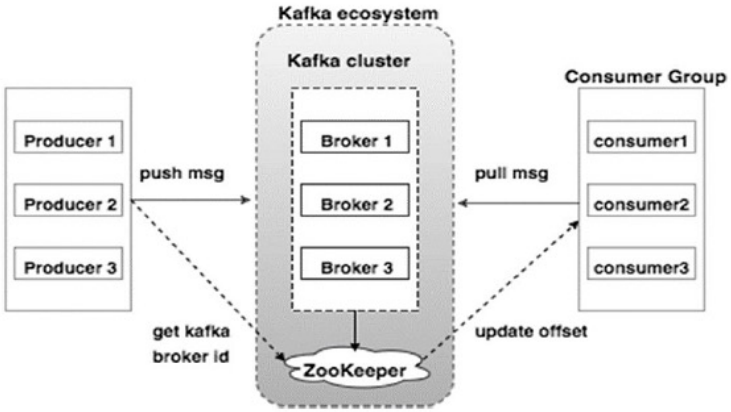
Picture Source: https://www.cloudamqp.com/blog/part1-rabbitmq-for-beginners-what-is-rabbitmq.html

Kafka

- **A distributed event store and streaming platform**
- Has servers and clients that communicate over TCP Network Protocol
- Can be deployed on hardware, VMs, containers, cloud environments
- Used by over 80% of the fortune 100

Use cases:

- Decouple dependencies by streaming events
- Messaging
- Location & activity tracking
- Commit log
- Log aggregation



- Server: is run as a cluster of servers that can span multiple datacenters
- Highly scalable and fault-tolerant
- Client: allows you to write distributed applications and microservers that read, write, and process streams of data in parallel

diagram source: https://www.tutorialspoint.com/apache_kafka/apache_kafka_cluster_architecture.htm

Objectives

- Install and configure RabbitMQ and Kafka in student cluster environment
- Create basic sender and receiver Python applications for RabbitMQ and Kafka to ensure each service is working
- Explore HPC uses cases for both services

Image Source: https://kafka.apache.org/

Image Source: https://www.rabbitmq.com/

RabbitMQ Install and Configuration

RabbitMQ on RHEL Installation Steps:

1. Import necessary RPM's
2. Configure a Yum repository for RabbitMQ
3. Install the RabbitMQ server and its dependencies
4. Create a RabbitMQ user
5. Create a Virtual Host for the RabbitMQ user to connect to
6. Set permissions, so the user and virtual host can recognize each other

```
[root@xenon4 rabbit]# python3 send.py
 [x] Sent 'Hello World!'
```

```
[root@xenon5 rabbit]# python3 receive.py
 [*] Waiting for messages. To exit, press CTRL+C
 [x] Received 'Hello World!'
```

Kafka Install and Configuration

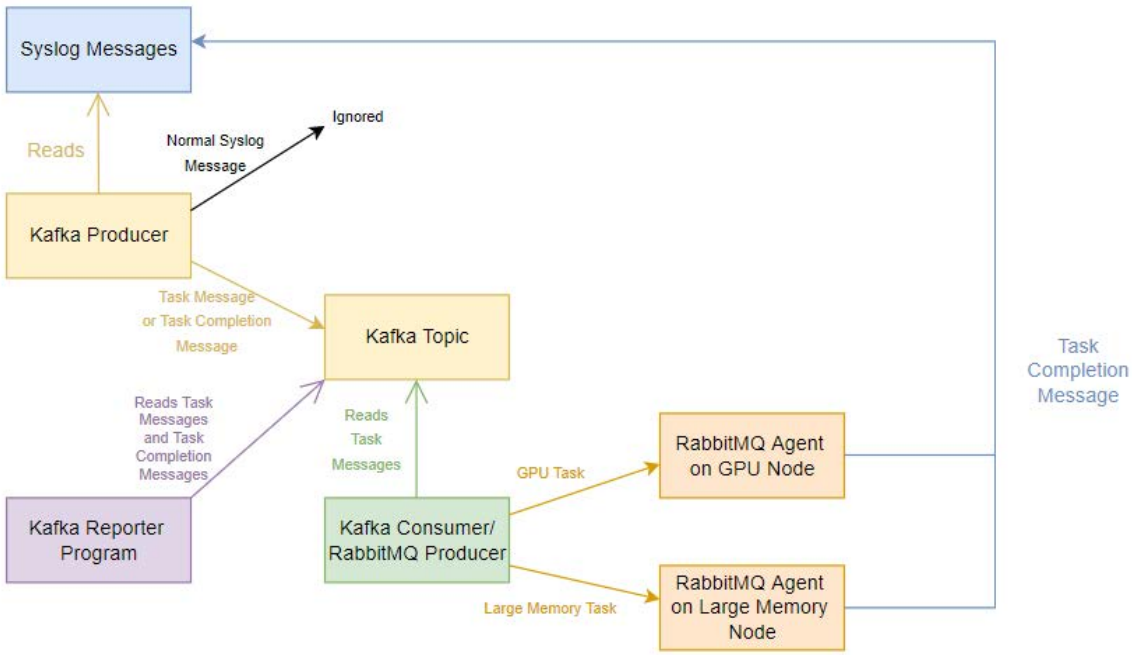
```
[root@radon4 ~]# python3 producerApp.py
sending message...
message sent successfully...
```

```
received message =  ConsumerRecord(topic='test-topic'
partition=0, offset=3, timestamp=1660178191347, times
mp_type=0, key=None, value={'name': 'abc', 'email': '
c@example.com'}, headers=[], checksum=None, serialize
key_size=-1, serialized_value_size=43, serialized_hea
r_size=-1)
```

- Download latest Kafka release and extract it
- Create user to run Kafka and Zookeeper
- Start Kafka environment (create and start a service for both)
- To send messages, create producer and consumer programs on separate nodes using KafkaProducer / KafkaConsumer APIs

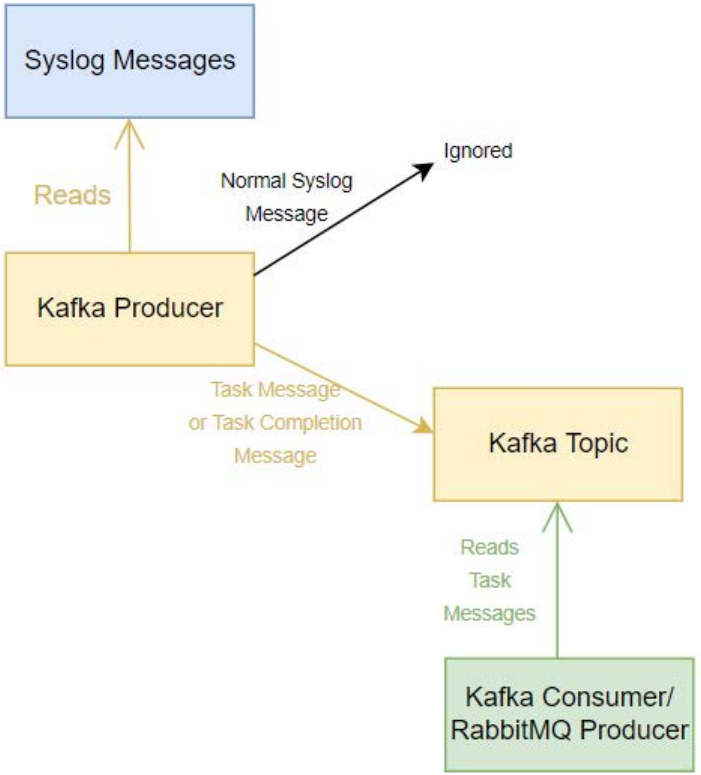
Example Use Case Model

- Besides sending messages, RabbitMQ and Kafka can also be used to send tasks
- These services could work together to send and record tasks being done
- **Objective**: Use Kafka and RabbitMQ to handle jobs issued by syslog

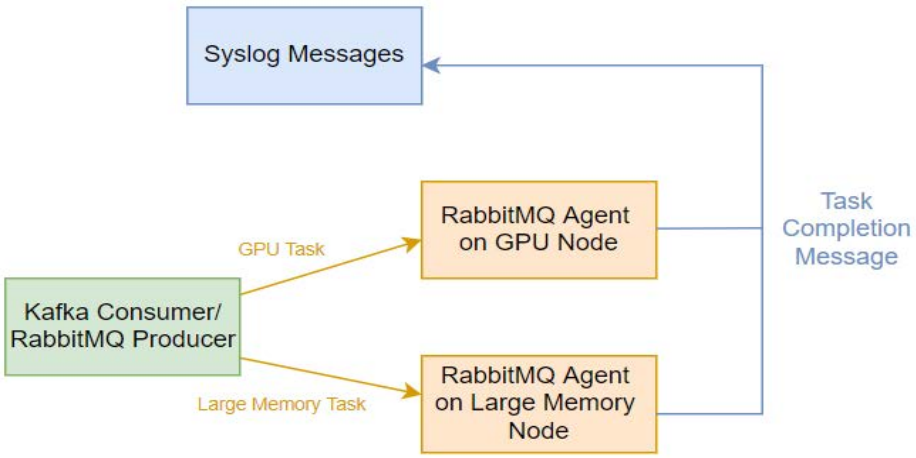


Transferring Task Messages

- Kafka Producer continually reads syslog messages
- Task message triggers Producer to publish to Kafka Topic
- Kafka Consumer reads from topic and passes task message to RabbitMQ Producer



Delegating and Recording Tasks



- RabbitMQ sends task to appropriate agent
- Task completion message sent to syslog
- Kafka Recorder program lists when tasks were issued and completed

Challenges

- Filtering Messages
  - No straightforward method for filtering data sent into the Kafka topic
- Incorporating Kafka in demo
  - Limited access to large data sets
  - Made finding use case difficult
- Connecting RabbitMQ and Kafka
  - Because of their similar functionality, finding a practical model using both services to fit one use case was a challenge

Future Goals

- Explore clustering
  - Scalability
  - High Availability
- Explore additional clients and usage models
  - Other client libraries with RabbitMQ and Kafka (C++, Java, etc.)
  - Advanced Configurations (integrating Celery with RabbitMQ, KafkaStreams with Kafka, etc.)
- Data Retention and Management, particularly with Kafka

References

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- https://www.cloudamqp.com/blog/part1-rabbitmq-for-beginners-what-is-rabbitmq.html
- https://www.upsolver.com/blog/kafka-versus-rabbitmq-architecture-performance-use-case#:~:text=Kafka%20offers%20much%20higher%20performance,for%20big%20data%20use%20cases
- https://kafka.apache.org/
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- https://www.ibm.com/cloud/learn/message-brokers