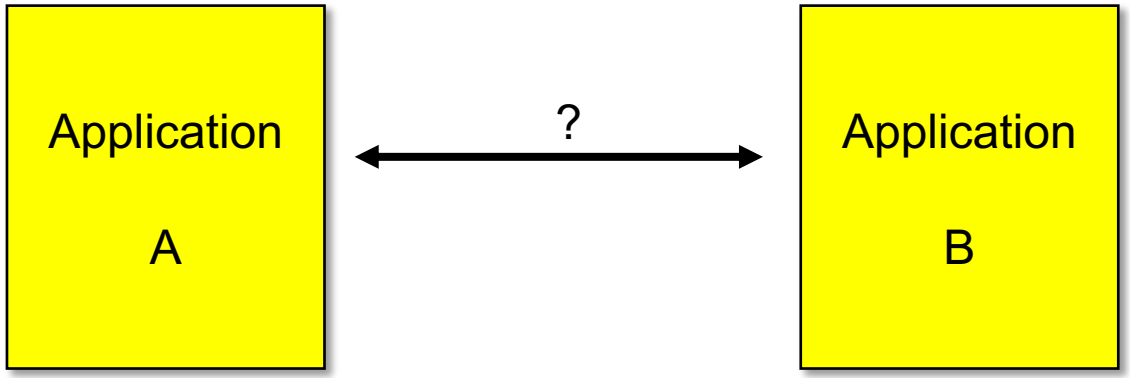
Service Integration Patterns

Enterprise Architectures for Big Data

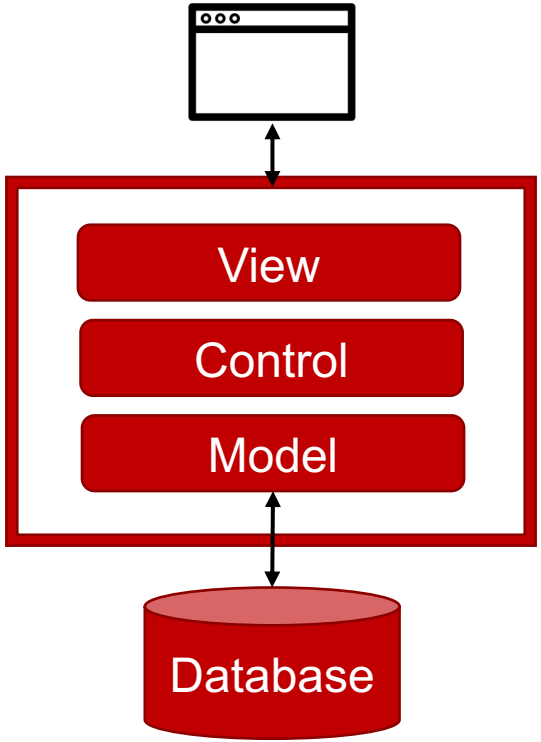
Problem

- How can I **integrate** multiple **distributed** applications or services so that they **work together** and can **exchange information**?

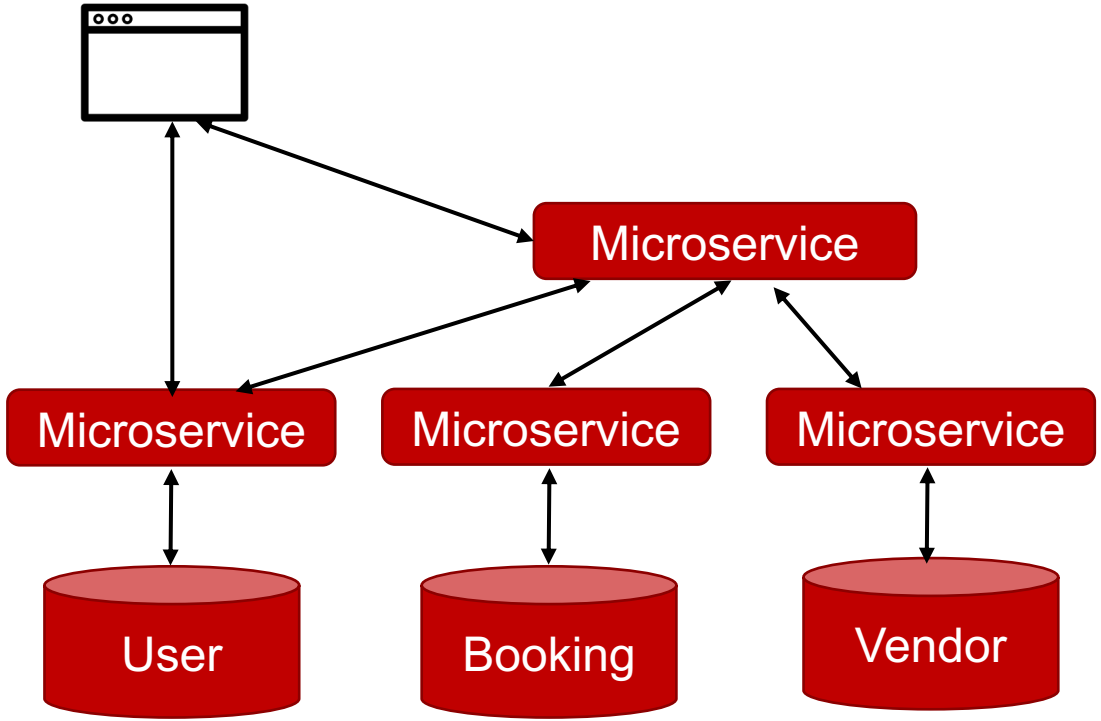


Monolithic vs. Microservice Architecture

Monolithic Architecture

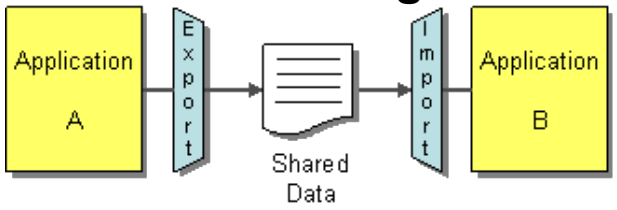


Microservice Architecture

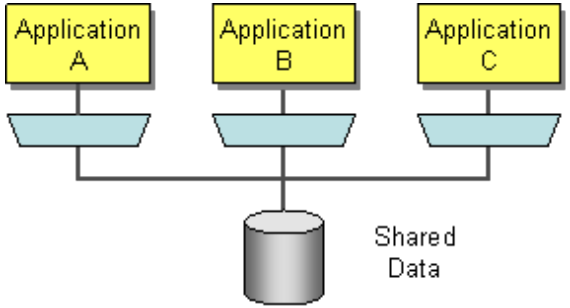


Integration Styles

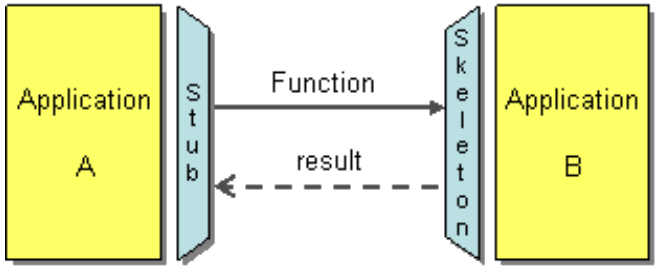
File Transfer Integration



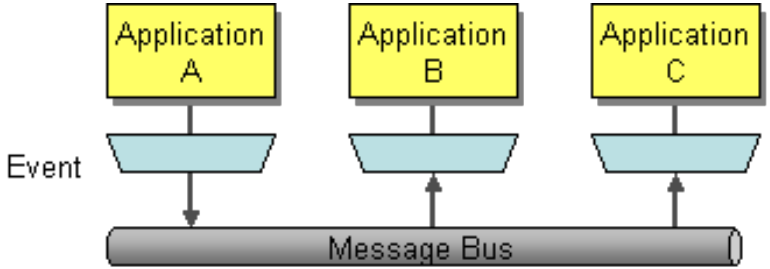
Shared Database

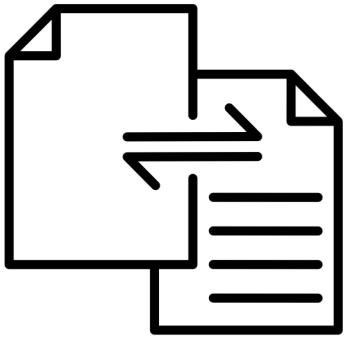


Remote Procedure Invocation



Message Queue

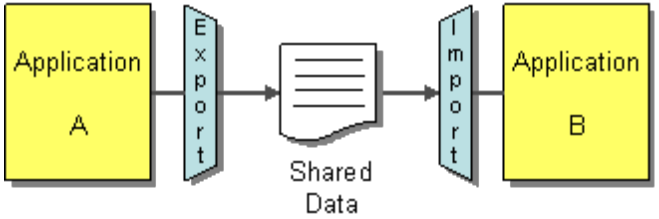




File Transfer Integration

File Transfer Integration

- **Problem**: How can I integrate multiple applications or services so that they work together and can exchange information?



- **Solution**: Have each application produce **files** containing information that other applications need to consume.
- Integrators take the responsibility of transforming files into different formats.
- Produce the files at regular intervals according to the nature of the business.

File Transfer Integration

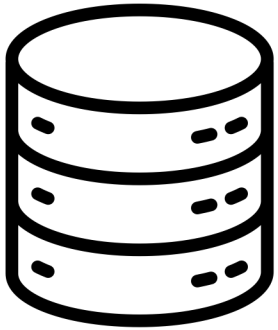
Pro

- Simplicity
- All programming languages have ways to read and write files
- Decoupling of applications
- Allow asynchronous communication
- Scalable for large data
- Scalable through Network File System (NFS), Hadoop (HDFS) or Cloud (AWS S3)
- Good for Batch processing

Con

- Needs common access to files/folders or cloud file storage
- Different file formats
- Agreement of filenames, folders, and formats
- No notification of other application
- Lacks timeliness (high latency)
- No concurrent write access

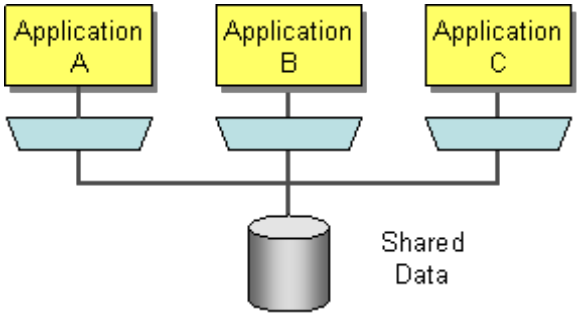
Source: Hohpe & Woolf (2004)



Shared Database

Shared Database

- **Problem**: How can I integrate multiple applications or services so that they work together and can exchange information?



- **Solution**: Integrate applications by having them store their data in a single **Shared Database**.

Shared Database

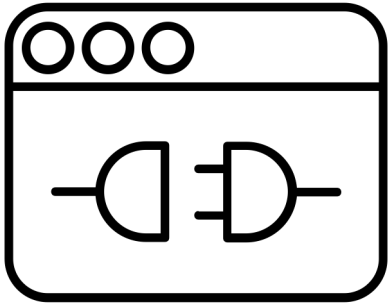
Pro

- Timely data
- Consistency
- Concurrent Read-Write Access (ACID Transactions)
- No file formats
- Integrated through
- Often powerful query language (like SQL)

Con

- Needs a unified schema
  - High Coupling
  - Applications might have their own schema
- Database might be a bottleneck
  - Especially for globally distributed systems
- No sharing of functionality (just data)
- No notification of other application
- Needs access to database (firewall, views, rights, …)
- Might allow complex SQL queries that will slow down the source system
- Tied to specific database technology

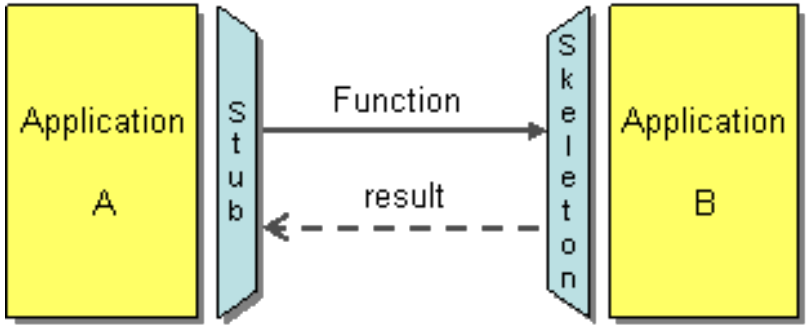
Source: Hohpe & Woolf (2004)



Remote Procedure Invocation
Web API

Remote Procedure Invocation
Web API

- **Problem**: How can I integrate multiple applications so that they work together and can exchange information?



- **Solution**: Develop each application as a large-scale object or component with encapsulated data.
- Provide an **interface** to allow other applications to interact with the running application.

Source: Hohpe & Woolf (2004)

REpresentational State Transfer (REST)

- Architectural style inspired by the Web
- **Resource**: things that the service itself knows about, like Customers
- Each Resource has a **Uniform Resource Locator (URL)**
- Different **Representations** of Resources
- How Resources are represented externally is completely decoupled from how they are stored internally
  - E.g. Internally relational DB, externally JSON or HTML
- Web (HTTP) for transport
- JSON (or XML) for representing/encoding

Hypertext Transfer Protocol (HTTP) Verbs

- Most common HTTP Methods:
  - GET Method Read (also used by Web Browsers)
  - POST Method Create (also used by Web Browsers)

- Only for APIs:
  - PUT Method Update
  - DELETE Method Delete

- CRUD = Create-Read-Update-Delete
- APIs can just use GET and POST HTTP Methods!

Hypertext Transfer Protocol (HTTP) Verbs

GET Method

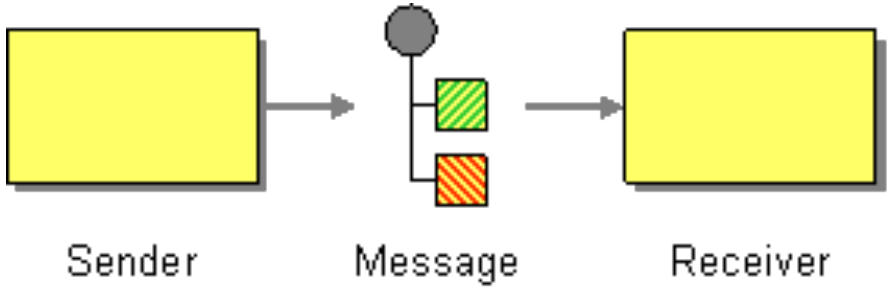
- Request data from a specified resource
- Query string (name/value pairs) in the URL of a GET request (in the address bar of the browser)
- Values: Only ASCII characters
- Length restrictions (maximum URL length is 2048 characters)
- Can be cached
- Can be bookmarked
- Reload is harmless (Idempotent)

POST Method

- Send data to create (update / delete) a resource
- When you submit a form in the browser
- Values: No restriction
- No length restrictions
- Never cached
- Cannot be bookmarked
- Reload: Data will be resubmitted

Messages

- **Subproblem**: How can two applications be connected by sending and receiving pieces of information?



- **Solution**: Package the information into a **Message**, a data record that the sender can transmit.

Example of JSON

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
}
```

Example of XML

```
<person>
  <firstName>John</firstName>
  <lastName>Smith</lastName>
  <age>25</age>
  <address>
    <streetAddress>21 2nd Street</streetAddress>
    <city>New York</city>
    <state>NY</state>
    <postalCode>10021</postalCode>
  </address>
</person>
```

Remote Procedure Invocation - Web API

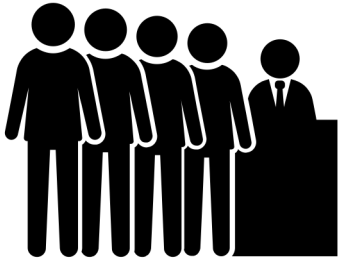
Pro

- Easy to use
- Ubiquitous
- Nearly all languages have a way to use Web APIs
- Sharing of functionality
- Encapsulation of data
- Timely response (However, compared to normal procedures: RPCs have network latency)

Con

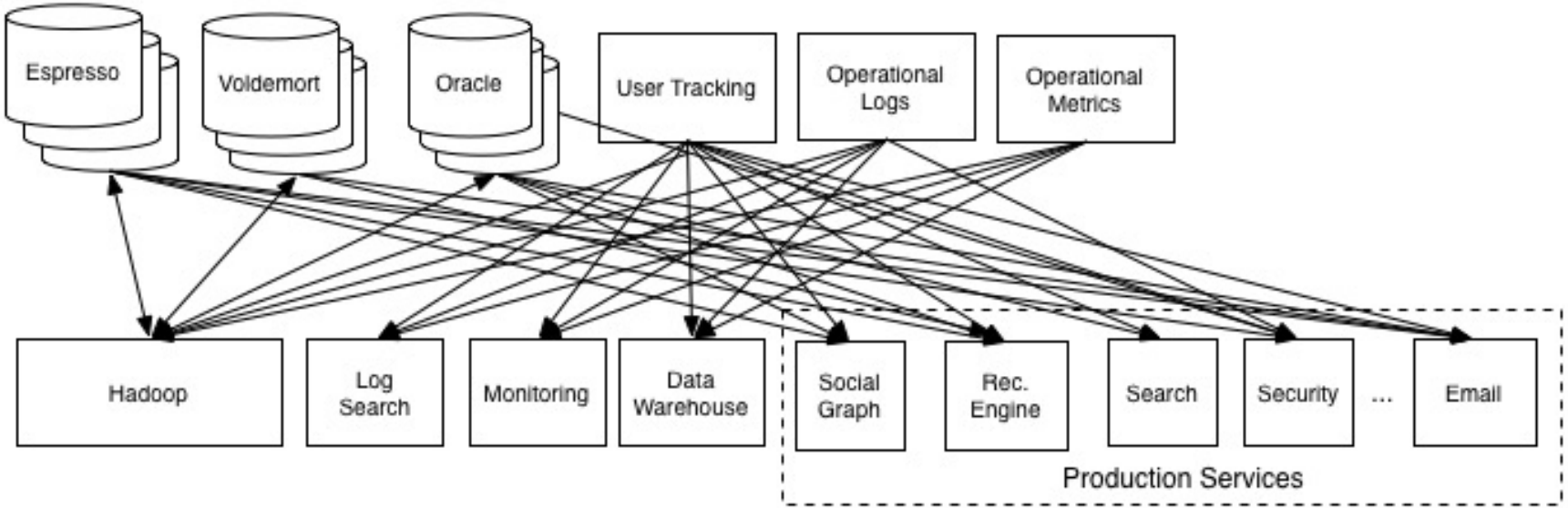
- Only request-response
- Only one-to-one connection
- Risk of tight coupling
- If response takes a long time, requesting application is blocked
- No asynchronous communication
- Receiver needs to understand message format
- Risk of changing message format

Source: Hohpe & Woolf (2004)

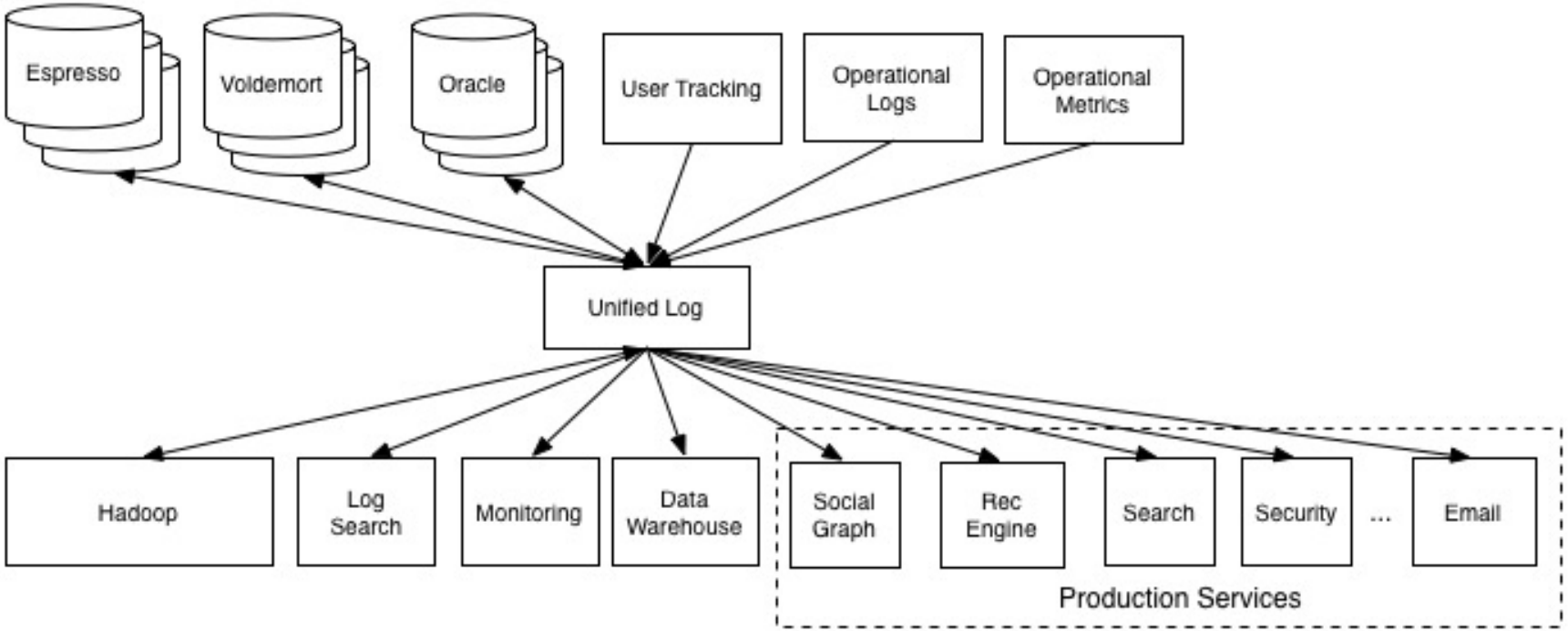


Message Queue

Tightly Coupled Systems

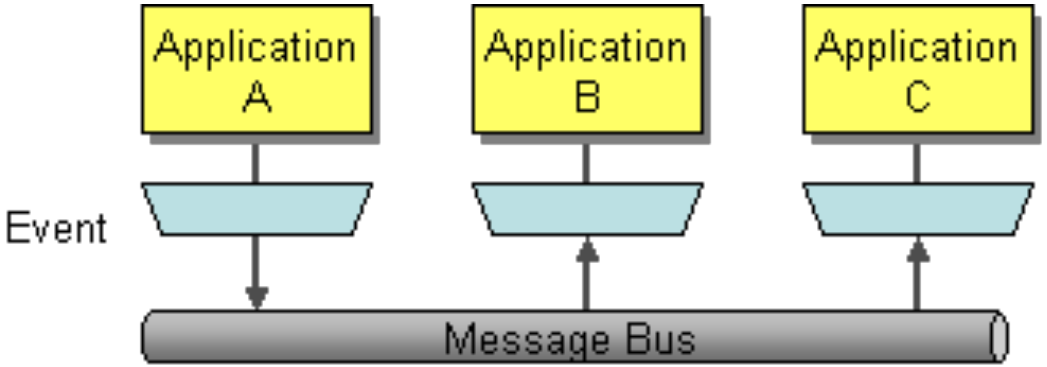


Decoupled Systems through a Message Queue



Messaging

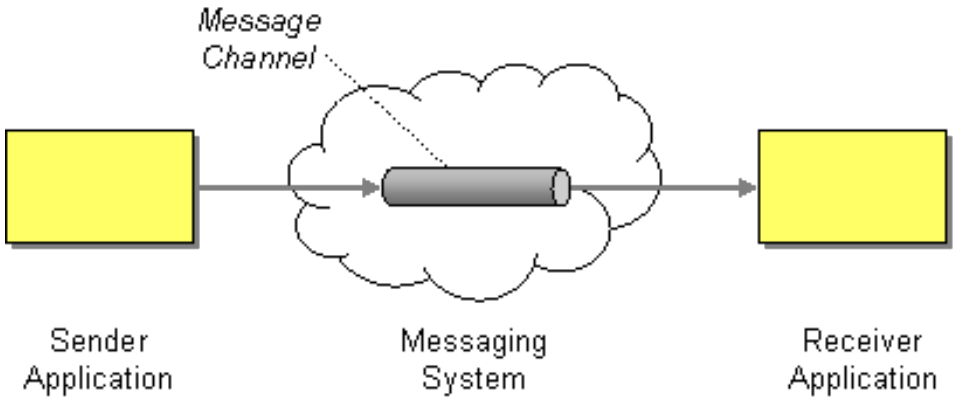
- **Problem**: How can I integrate multiple applications so that they work together and can exchange information?



- **Solution**: Use **Messaging** to transfer packets of data frequently, immediately, reliably, and **asynchronously**, using customizable formats.

Message Queue / Channel

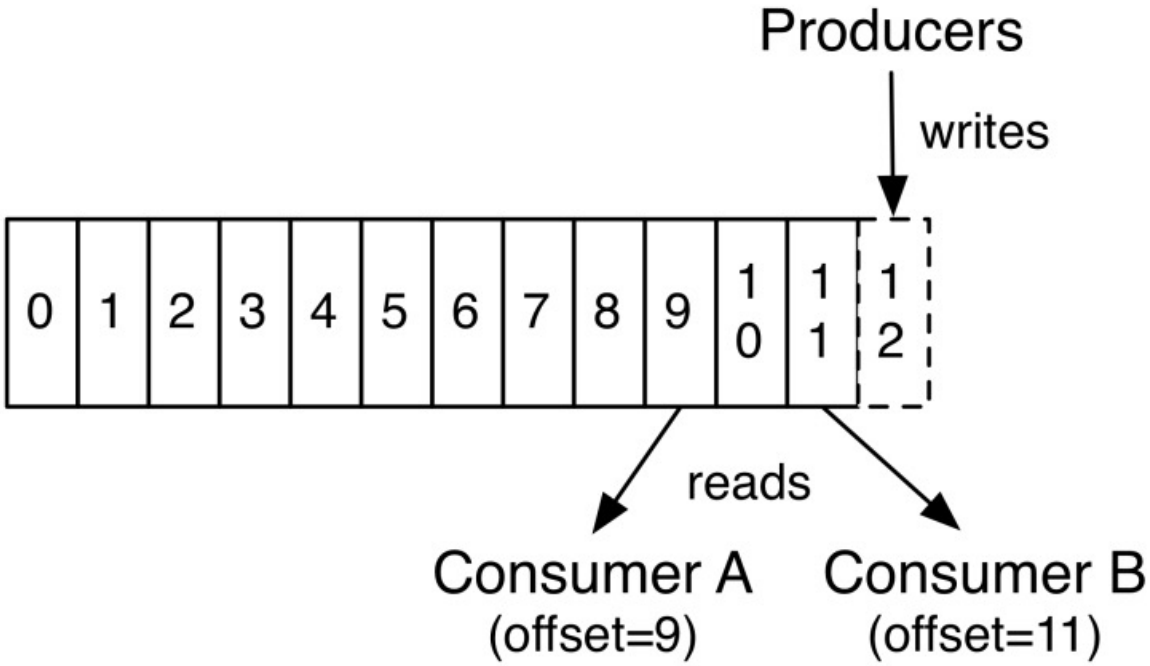
- **Subproblem**: How does one application communicate with another using messaging?



- **Solution**: Connect the applications using a **Message Queue**, where one application writes information to the channel and the other one reads that information from the channel.

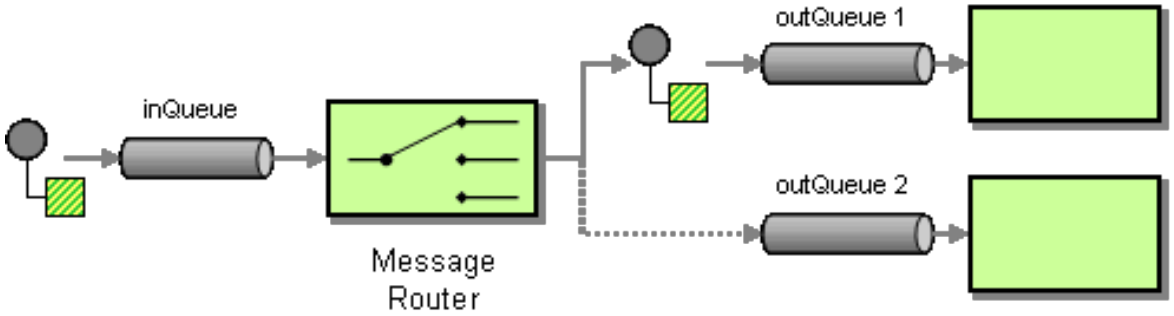
Source: Hohpe & Woolf (2004)

Log-structured Message Queue



Message Router

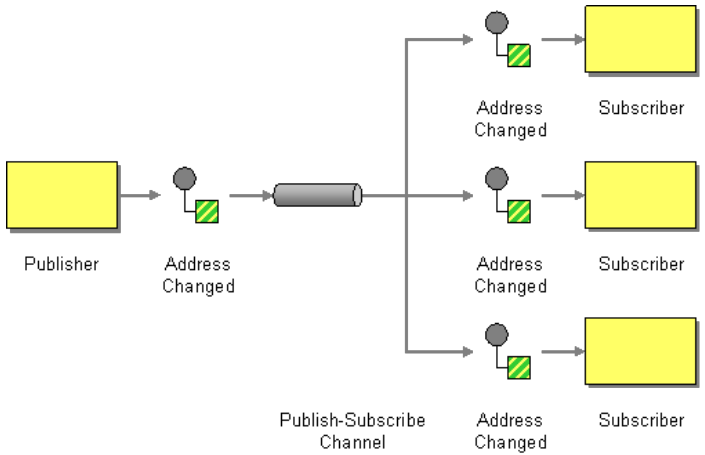
- **Subproblem**: How can you decouple individual processing steps so that messages can be passed to different filters depending on a set of conditions?



- **Solution**: Insert a special filter, a **Message Router**, which consumes a Message from one Message Channel and republishes it to a different Message Channel channel depending on a set of conditions.

Publish-Subscribe Channel

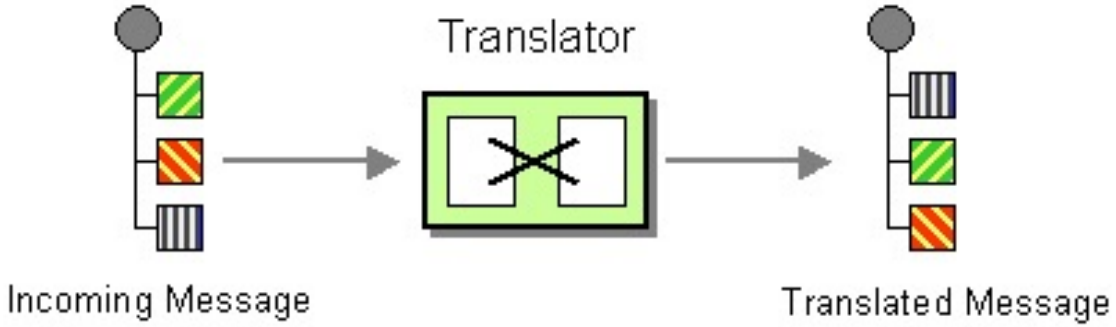
- **Subproblem**: How can the sender broadcast an event to all interested receivers?



- **Solution**: Send the event on a **Publish-Subscribe Channel**, which delivers a copy of a particular event to each receiver.

Message Translator

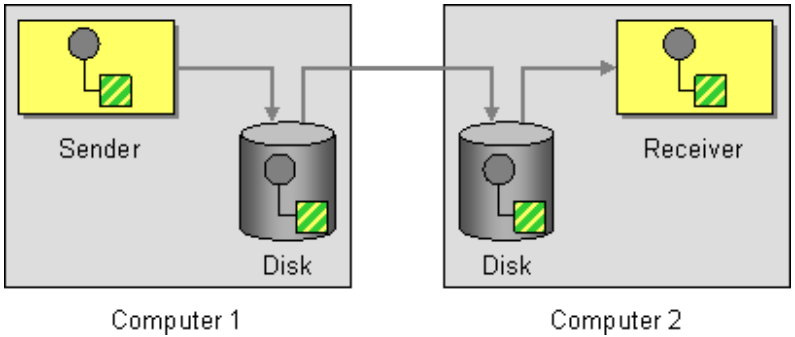
- **Subproblem**: How can systems using different data formats communicate with each other using messaging?



- **Solution**: Use a special filter, a **Message Translator**, between other filters or applications to translate one data format into another.

Guaranteed Delivery

- **Subproblem**: How can the sender make sure that a message will be delivered, even if the messaging system fails?



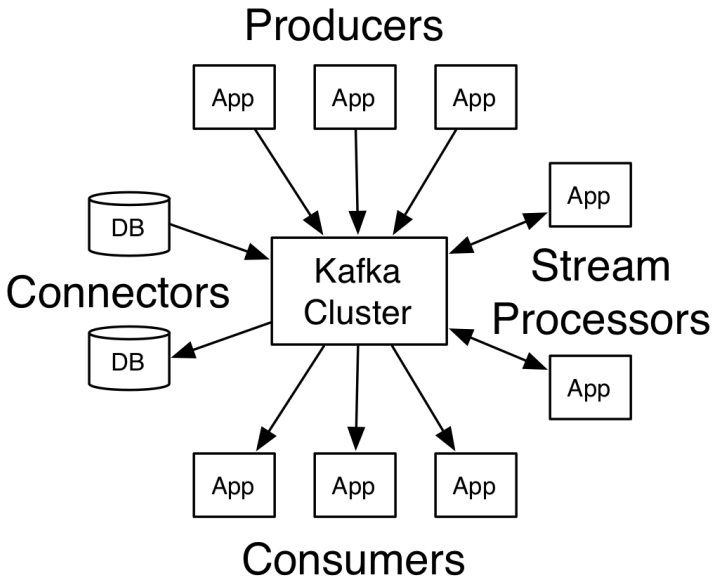
- **Solution**: Use **Guaranteed Delivery** to make messages persistent so that they are not lost even if the messaging system crashes.

Message Queues Systems

- Apache Kafka
- AWS Simple Queue Service (SQS)
- RabbitMQ
- TIBCO Enterprise Message Service
- IBM MQ
- Anypoint MQ (Mulesoft)
- Apache ActiveMQ
- Redis
- ...

Apache Kafka

- Massively scalable publish-subscribe message queue



APACHE kafka™
A distributed streaming platform

Message Queue

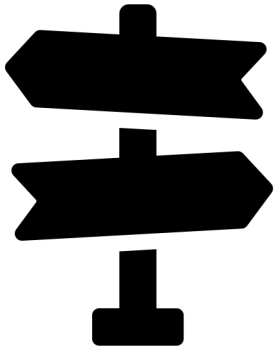
Pro

- Decoupling of services
- Allows asynchronous communication
- Broadcasting capability (1-to-n)
- Scalable
- Relatively timely
- Guaranteed only-once delivery
- Translation of different message standards
- Allows stream processing

Con

- Complicated
- High overhead
- Hard to debug and test
- Difficult integration beyond firewalls
- Might have still some data latency
- Not ideal for big batch jobs with few large files as results
- Different standards and products

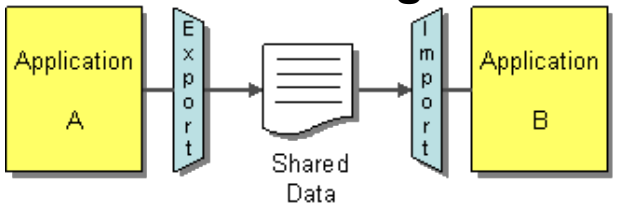
Source: Hohpe & Woolf (2004)



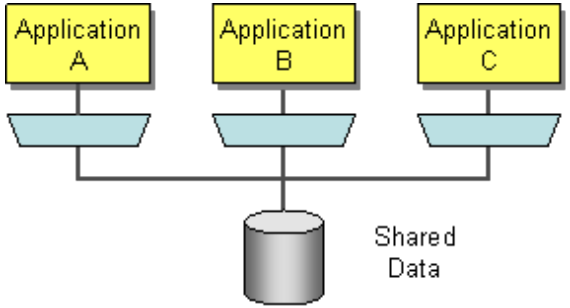
Decision Criteria for Integration Styles

Integration Styles

File Transfer Integration



Shared Database



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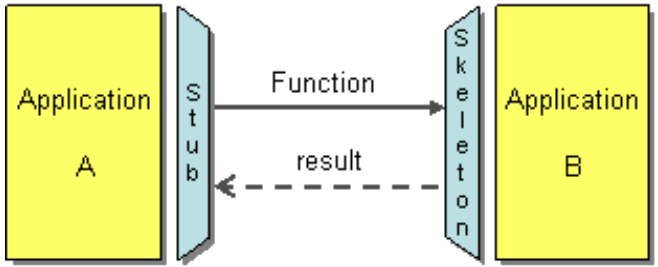
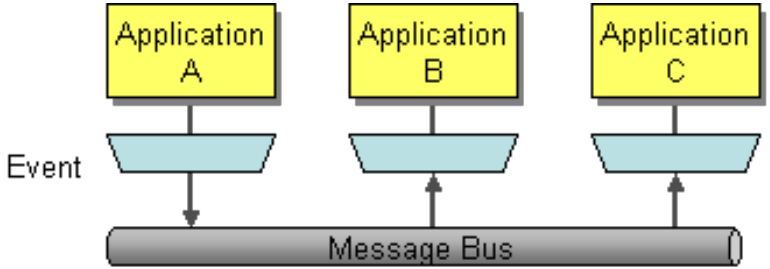


Message Queue



Decision Criteria for Integration Styles

1. Application coupling
2. Integration simplicity
3. Integration technology
4. Data format
5. Data timeliness
6. Data or functionality
7. Asynchronicity

Source: Hohpe & Woolf (2004)

Decision Criteria for Integration Styles

1. Application coupling
   - Even integrated applications should **minimize their dependencies** on each other so that each can evolve without causing problems for the others.
2. Integration simplicity
   - Developers should strive to **minimize changing the application** and minimize the amount of **integration code** needed.
3. Integration technology
   - Different integration techniques require varying amounts of **specialized software and hardware**.
   - These special tools can be expensive, can lead to vendor lock-in, and increase the burden on developers to understand how to use the tools to integrate applications.

Source: Hohpe & Woolf (2004)

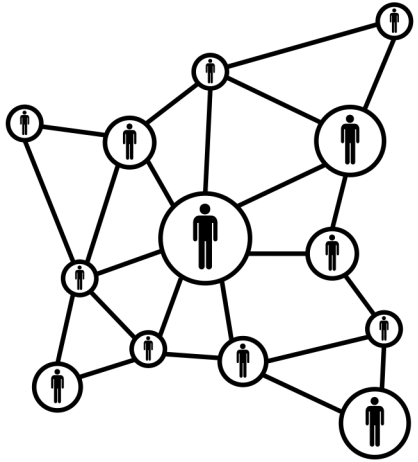
Decision Criteria for Integration Styles

4. Data format
   - Integrated applications must agree on the format of the data they exchange, or must have an intermediate translator to unify applications that insist on different data formats.
   - A related issue is **data format evolution and extensibility**—how the format can change over time and how that will affect the applications.
5. Data timeliness
   - Integration should **minimize the latency** between when one application decides to share some data and other applications have that data.
6. Functionality Sharing
   - Integrated applications may not want to simply share data, they may wish to **share functionality** such that each application can invoke the functionality in the others

Source: Hohpe & Woolf (2004)

Decision Criteria for Integration Styles

7. Asynchronicity
   - Procedure may not want to **wait for the subprocedure to execute**
   - It may want to invoke the subprocedure asynchronously, starting the subprocedure but then letting it **execute in the background**.



Conway's law

Conway's law

“Any organization that designs a system […] will produce a design whose structure is a copy of the **organization's communication structure**.”

Melvin E. Conway