JeroMF

A Software Development Framework for Building Distributed Applications Based on Microservices and JeroMQ

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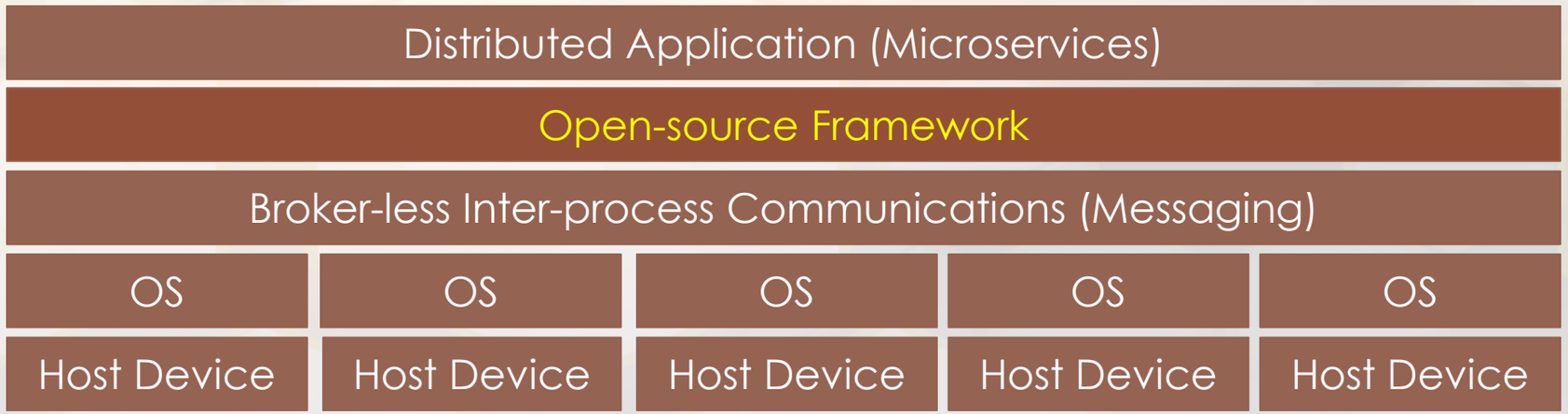
Motivation

- Distributed applications are pervasive in today's connected world.
- They can be hard to design, implement, test, deploy, scale, extend, and maintain.
- Service-oriented architectures showed some promise for distributed applications, but applications were still hard to implement, test, deploy, scale, extend, and maintain.
  - Simply splitting an application into multiple independent services can generate more artifacts to manage without necessarily obtaining testability, easier deployment, scalability, etc.
  - In fact, a haphazard refactoring of a distributed application into services may create more complexity.

Problem Statement

Create an open-source framework for distributed applications based on **Microservices** and using **broker-less inter-process communications** that

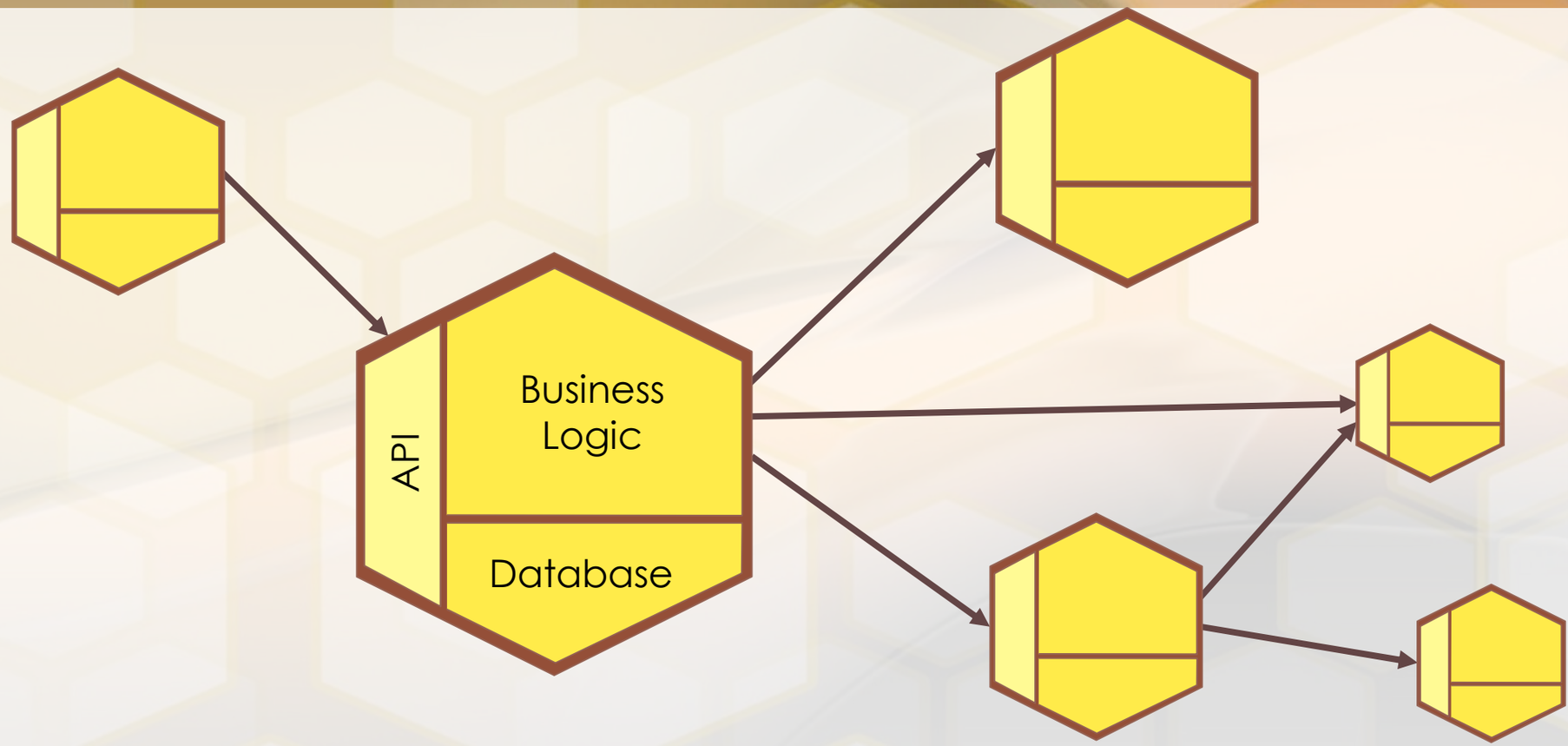
- Makes it easier for developers to create secure and reliable distributed applications
- Is flexible, extensible, and scalable
- Can be used for distributed applications running on heterogenous platforms
- Supports operational tools for managing distributed applications at runtime



Overview

- The Microservice Architecture Style
- Underlying Technology
- Architectural Overview of JeroMQ
- Sample Application
- JeroMF Processes
- JeroMF Services
- JeroMF Communication
- Extension Points
- Evaluation Through Use in Real-world Applications
- Conclusion

The Microservices Architectural Style



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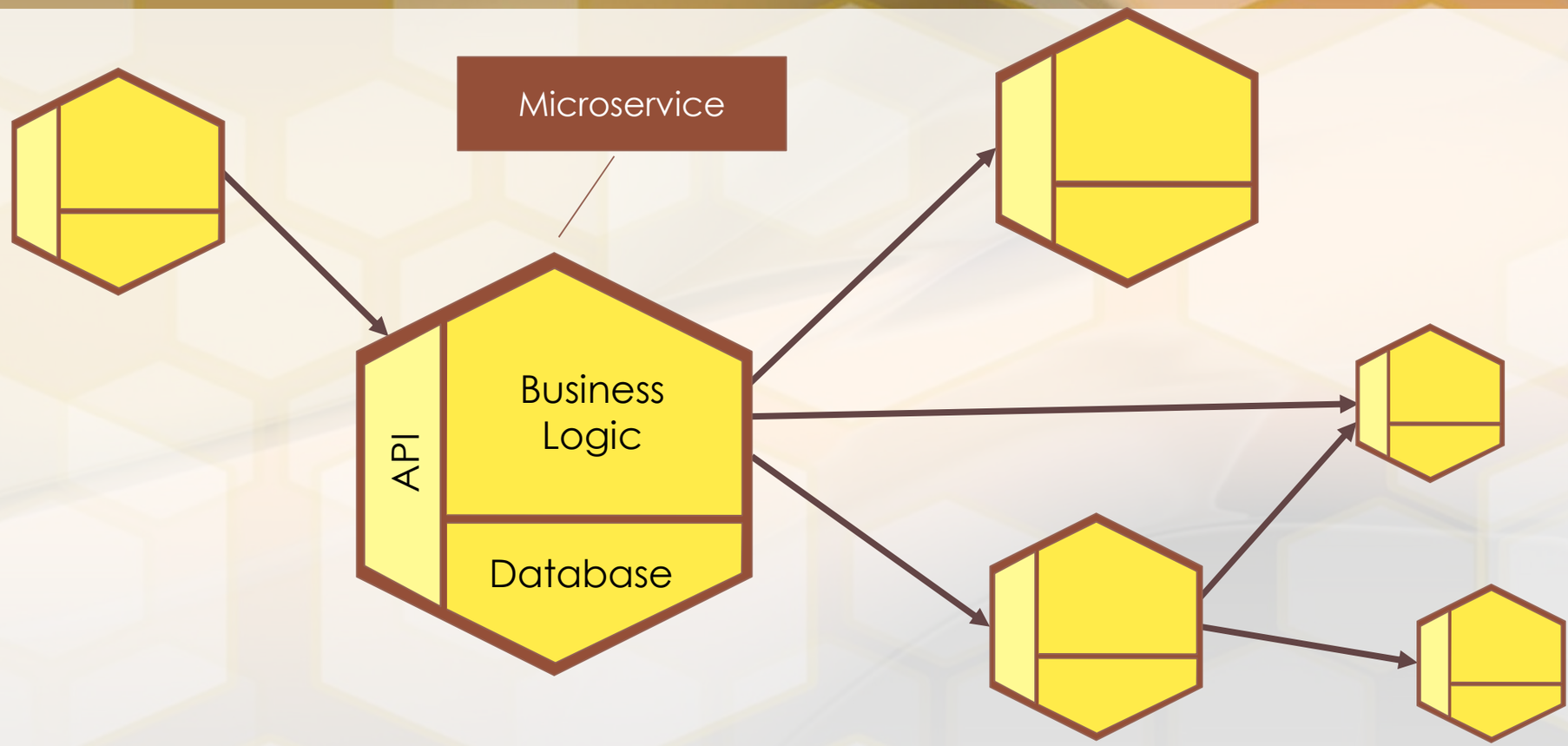

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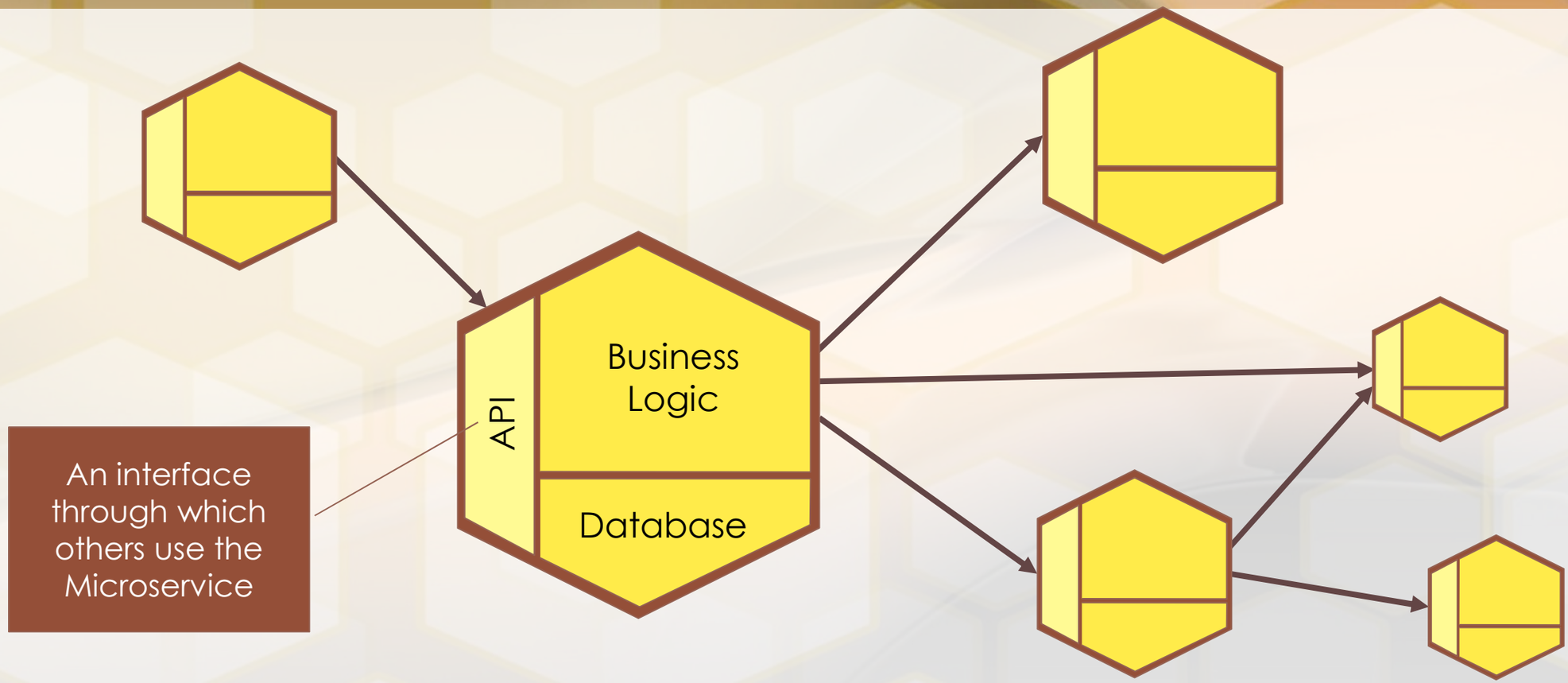

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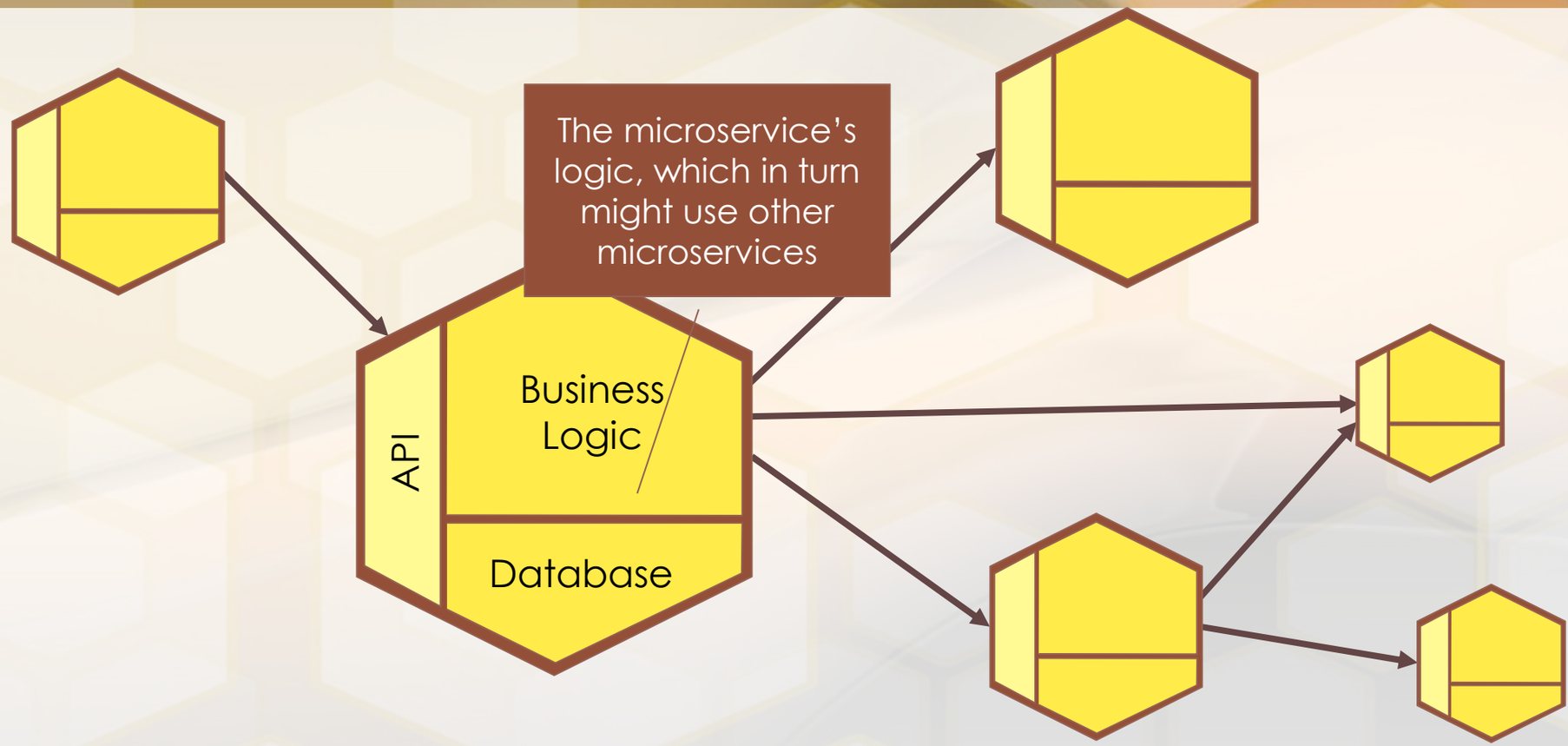

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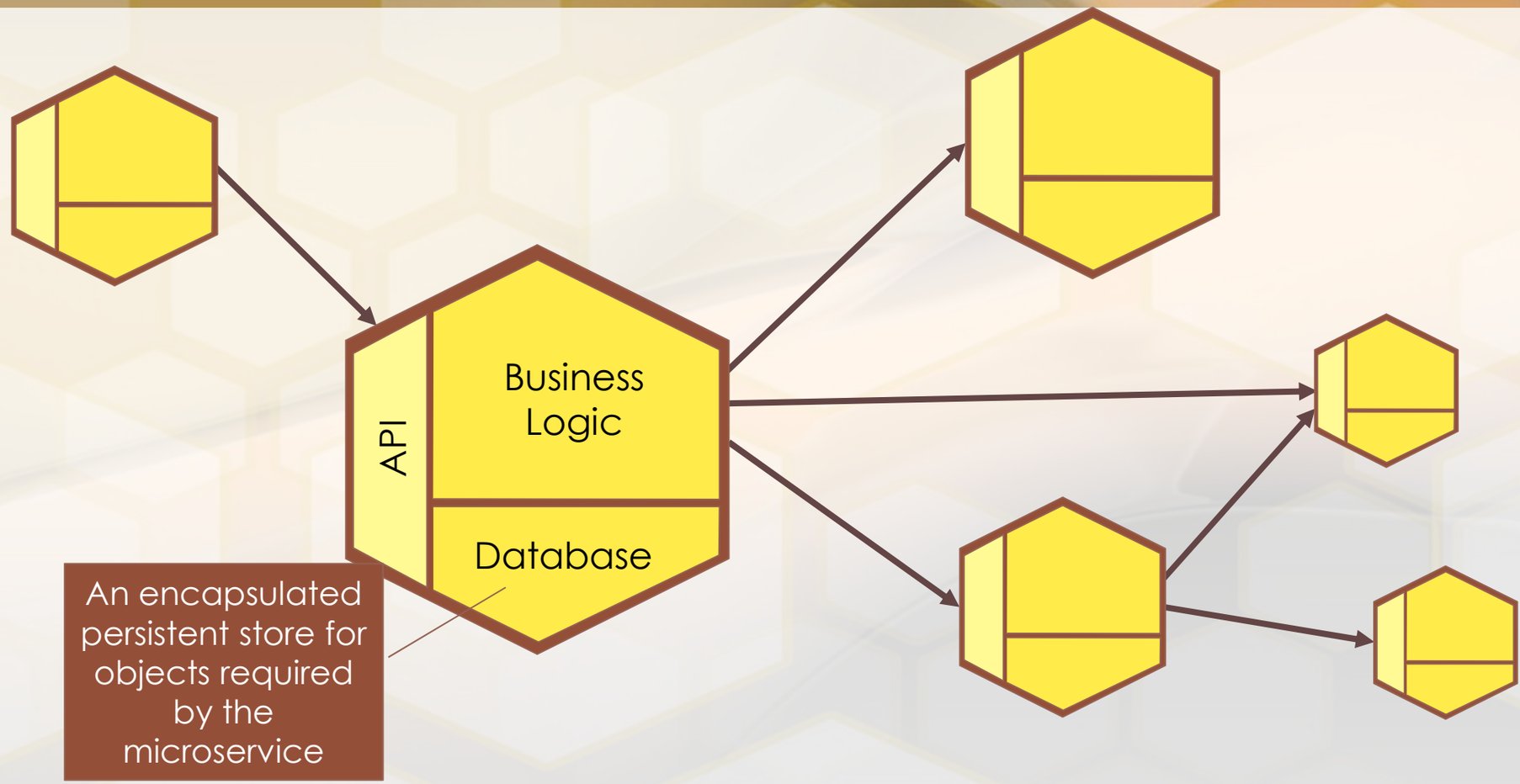


Characteristics of the Microservices Architectural Style

- Good modularity
  - **Highly cohesive**: each microservice should have a single responsibility
  - **Loosely coupled:** dependencies should be restricted to microservice API's and documented semantics
  - **Localization of design decisions**: individual design decisions should be encapsulated in one place. The microservices should encapsulate significant design decisions in place one.
  - **Modular reasoning**: A developer should be able to understand a microservice's functionality by looking at just its implementation.
- Good abstraction and encapsulation
- Testable and Maintainable
- Scalable
- Independently Deployable

Underlying Technology

- Communication Needs
  - Efficient and scalable
  - Reliable and secure
  - Widely available on all common computing platforms
  - Support for synchronous and asynchronous communications
  - Doesn't require intermediate processes (i.e., No brokers or message servers)
- Security Needs
  - Support for asymmetric and symmetric algorithms
  - Widely available on all common computing platforms
- Choices
  - ZeroMQ as a messaging library
  - BouncyCastle for encryption of application-level communications

ZeroMQ (and JeroMQ)

- ZeroMQ: A message library; not a messaging system
  - High-performance
  - Easy to use
  - Scalable
  - Supports true asynchronous communications
  - Ported to over 40 languages
- Supports multiple transportation layer protocols
  - Transmission Control Protocol (TCP)
  - Inter-process (Pipes)
  - Inter-thread (In-process communications)
- JeroMQ is a native Java port of ZeroMQ
- See http://zeromq.org and https://github.com/zeromq/jeromq-jms

Bouncy Castle Crypto API

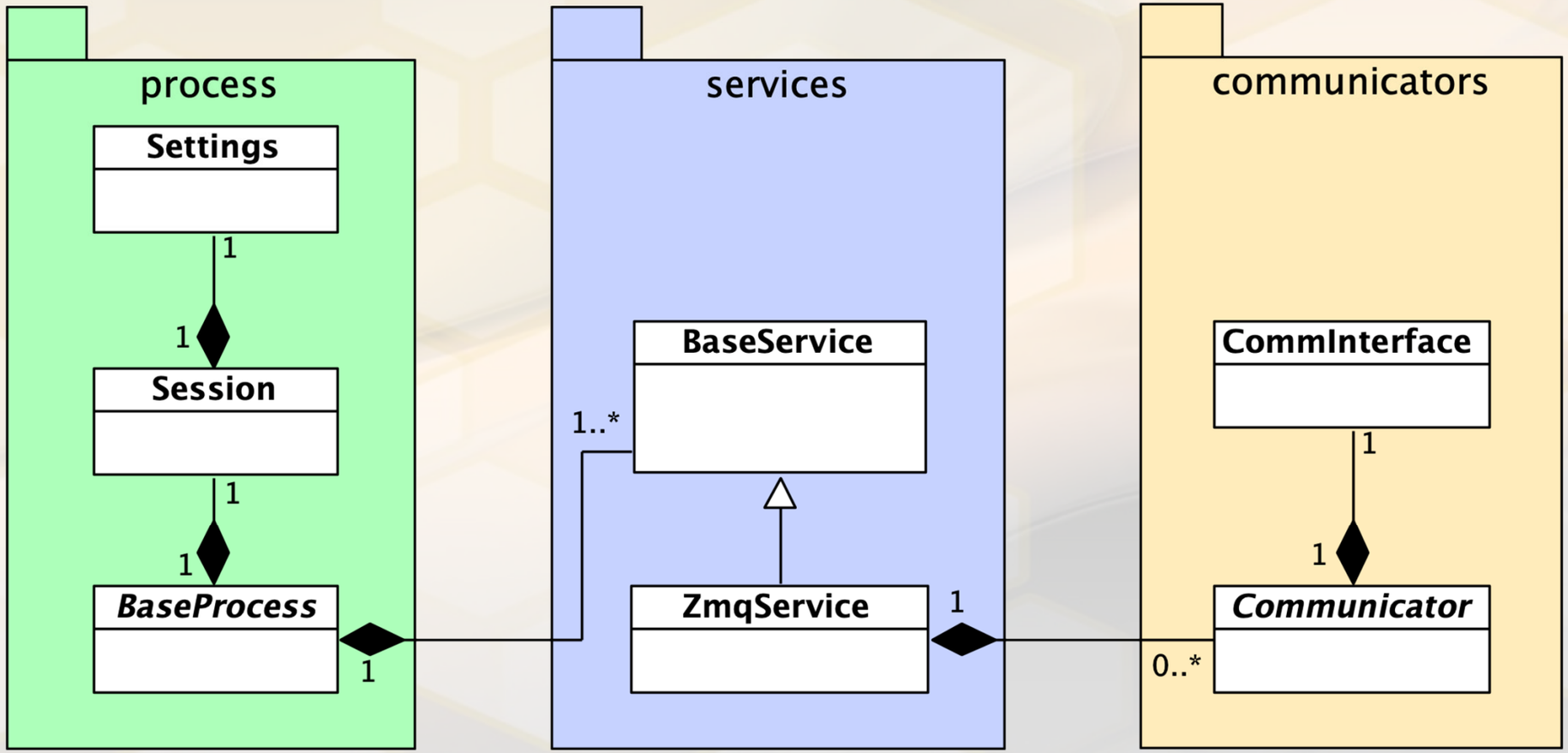
- Lightweight cryptography API for Java and C#
- A provider for the Java Cryptography Extension (JCE) and the Java Cryptography Architecture (JCA)
- Support for wide range of crypto algorithms.

- The Bouncy Castle Crypto APIs are maintained by an Australian Charity, the Legion of the Bouncy Castle Inc.
- See http://bouncycastle.org

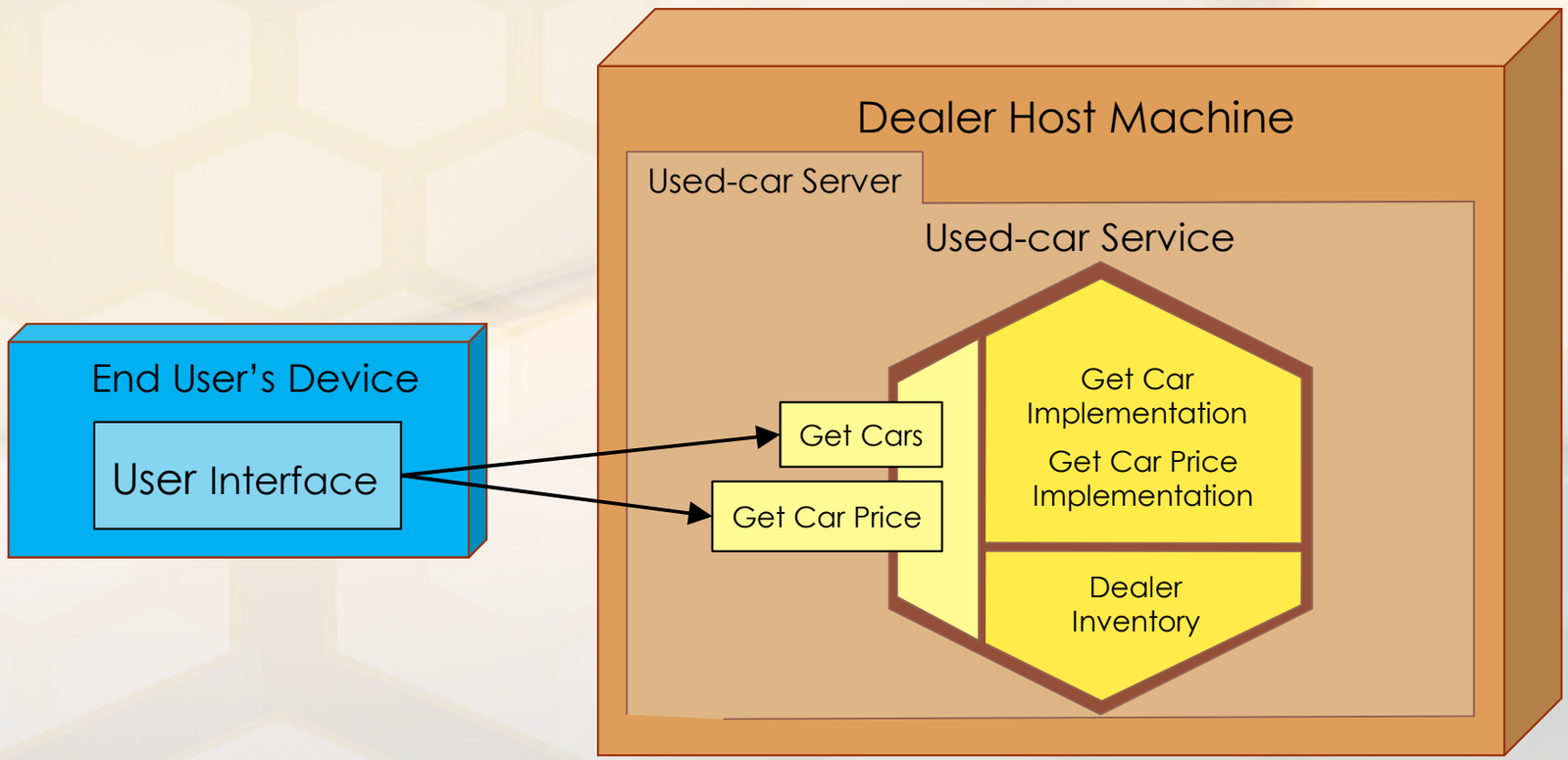
Initial Goals for JeroMF

- Make it easy for developers to
  - Setup containers (processes) of microservices
  - Manage service configurations
  - Create custom services
  - Define and implement reliable application-level communication protocols
  - Authenticate services and encryption application-level communications
  - Track service load and communication statistics
  - Test services and inter-service communications
- It should also allow operators to
  - Gracefully startup and shutdown services
  - Monitor the status of the services in a distributed application

JeroMF: Architectural Overview

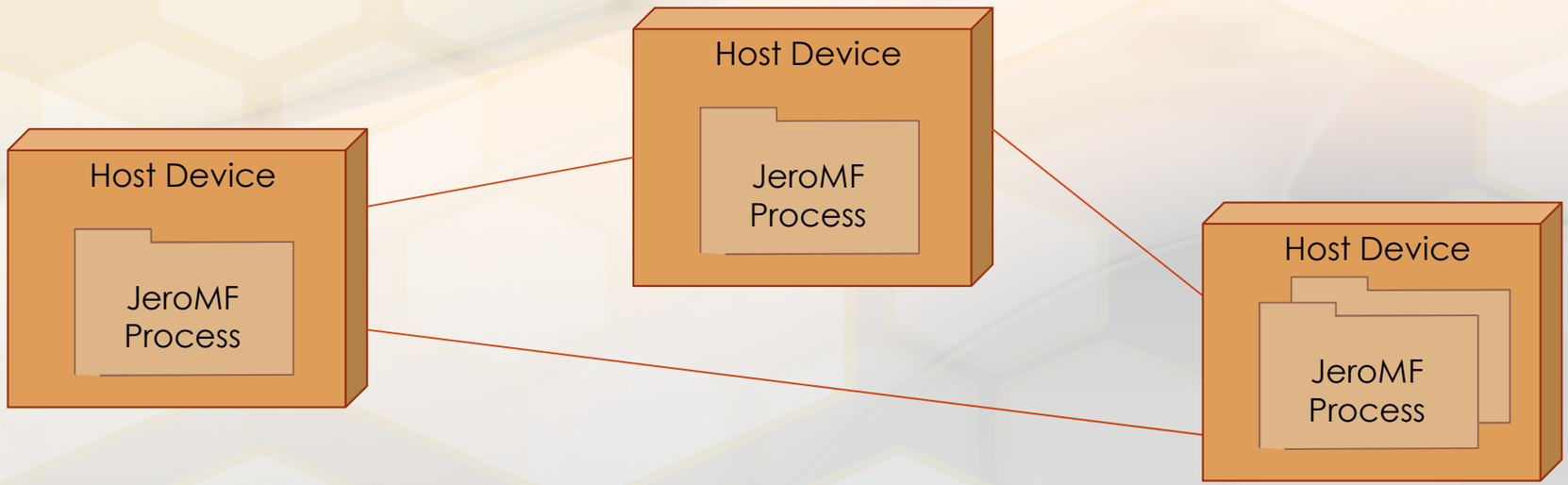


Sample Application

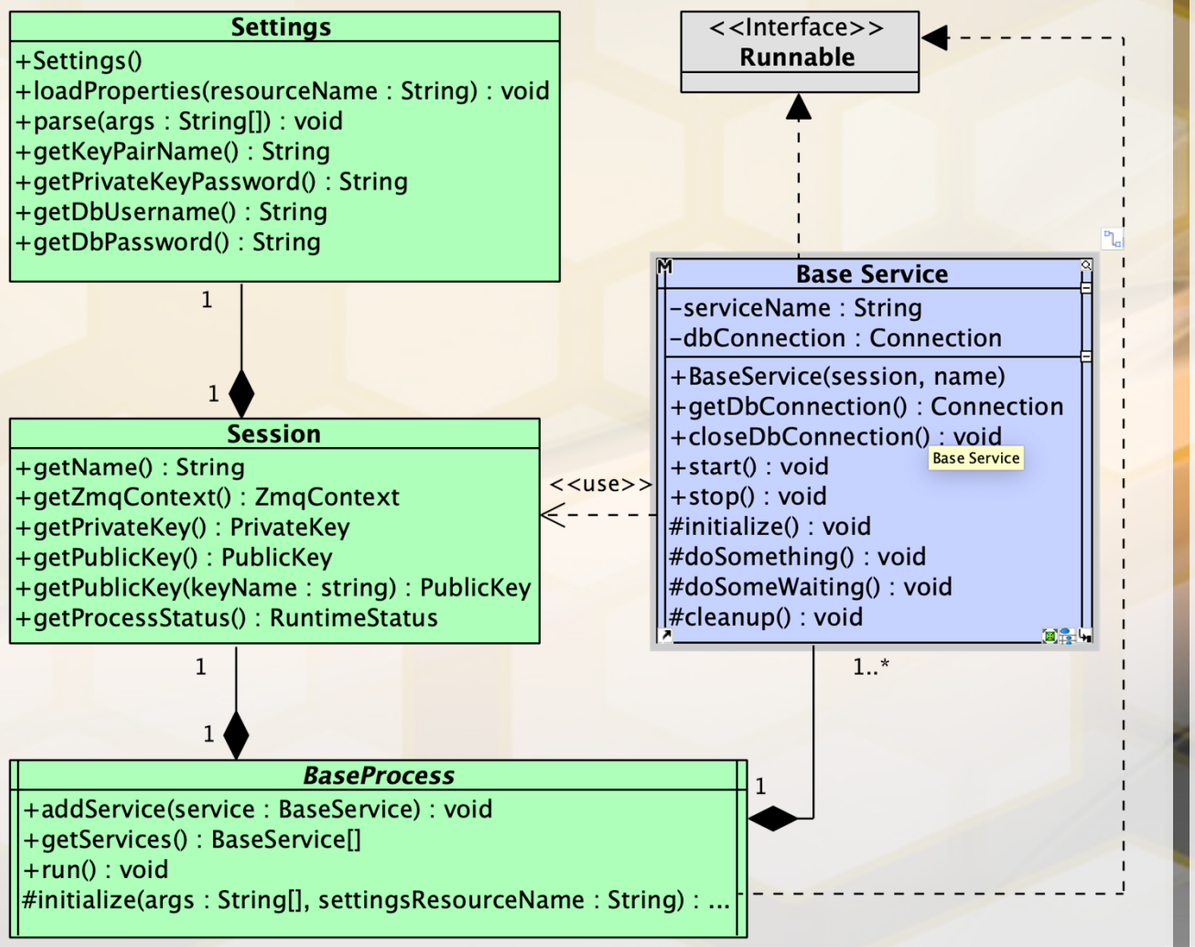


JeroMF Processes

- A JeroMF process
  - Is a container for one or more microservices
  - Holds process-level information, e.g. Session values and Settings
  - Does not need to be run on an application server or container platform
  - Can run on any platform with a JVM, including mobile devices



JeroMF Processes

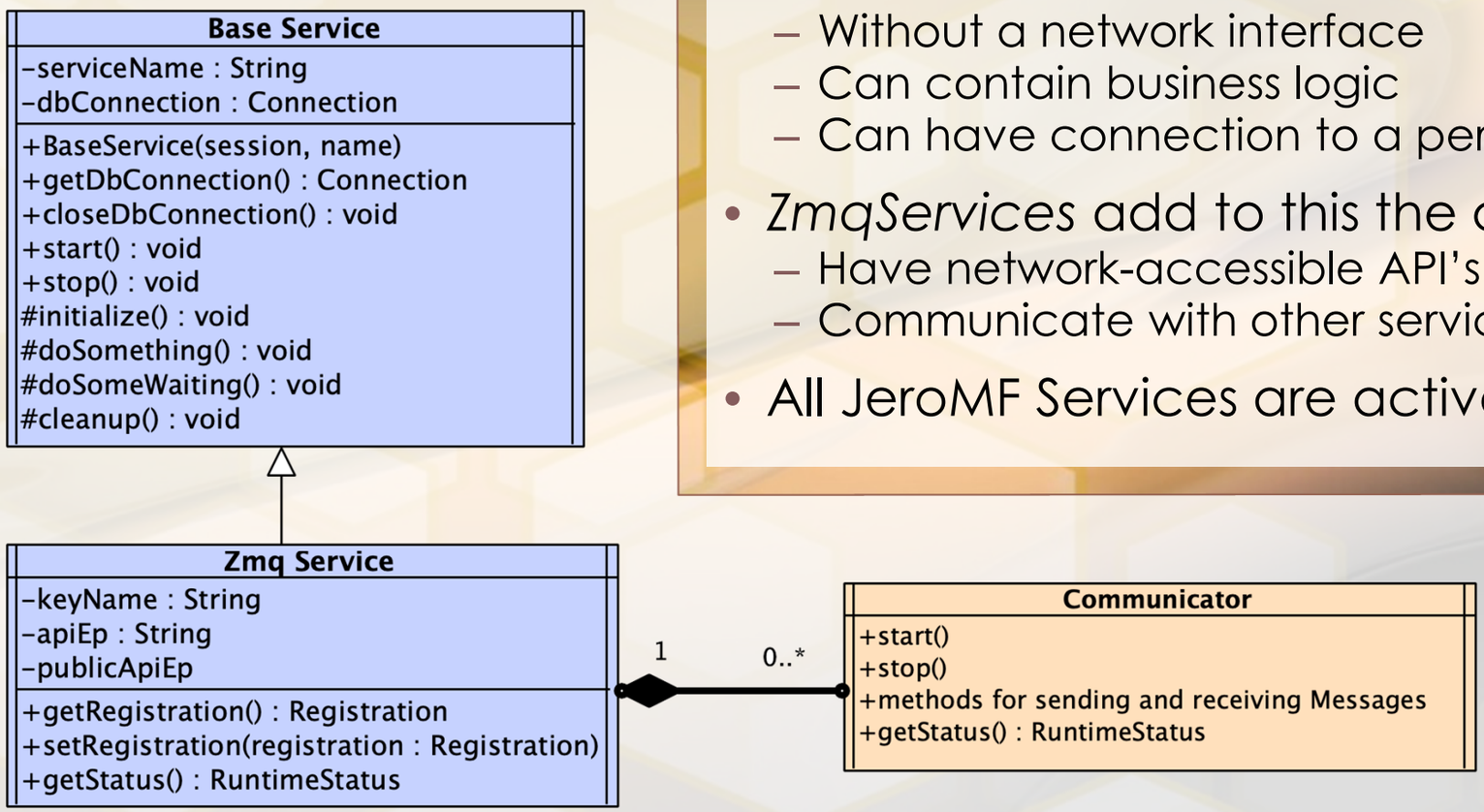


- A JeroMF process
  - Inherits from *BaseProcess*
  - Is a container for one or more microservices (*BaseService*)
  - Holds process-level information, i.e., *Session* and *Settings*
  - Uses a template method pattern to ensure that it is "*open for extension but closed to modification*"
  - Does not need to be run on an application server or container platform
  - Can run on any platform with a JVM, including mobile devices

JeroMF Processes

```
public class UsedCarServer extends BaseProcess {
  public static void main(String[] args){
    UsedCarServer process=new UsedCarServer();
    try {
      process.initialize(args,"server.config");
      UsedCarService service =
                new UsedCarService(instance.getSession(),"UsedCarsService");
      process.addService(service);
      process.run();
    }
    catch (Exception e) {e.printStackTrace(); }
    finally { process.cleanup(); }
  }

  @Override
  protected Settings createSettings() {
    return new UsedCarSettings();
  }
}
```

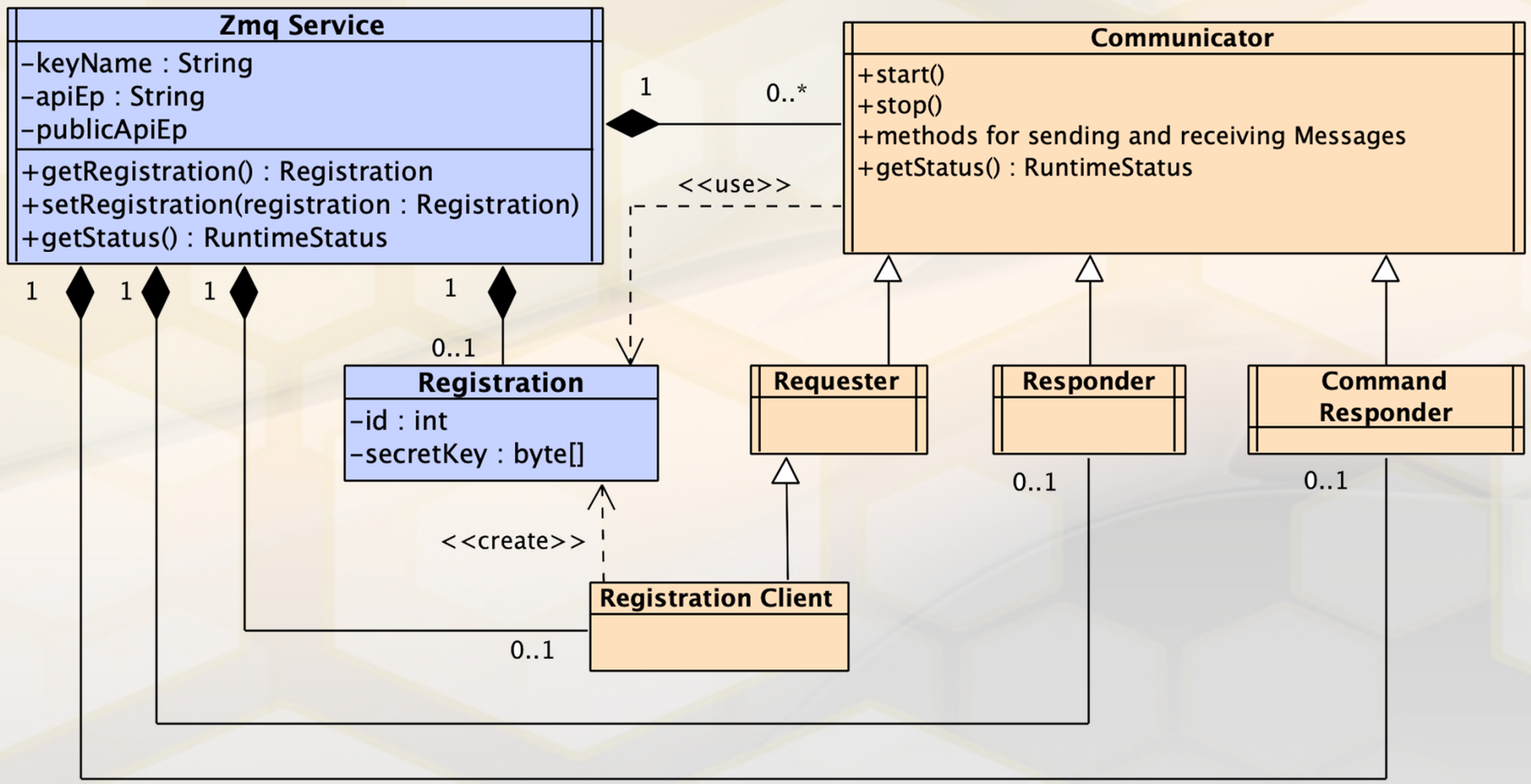
JeroMF Services



- *BaseServices* are microservices
  - Without a network interface
  - Can contain business logic
  - Can have connection to a persistent dataset
- *ZmqServices* add to this the ability to
  - Have network-accessible API's
  - Communicate with other services
- All JeroMF Services are active objects

- They use a template method pattern to ensure extensibility through specialization

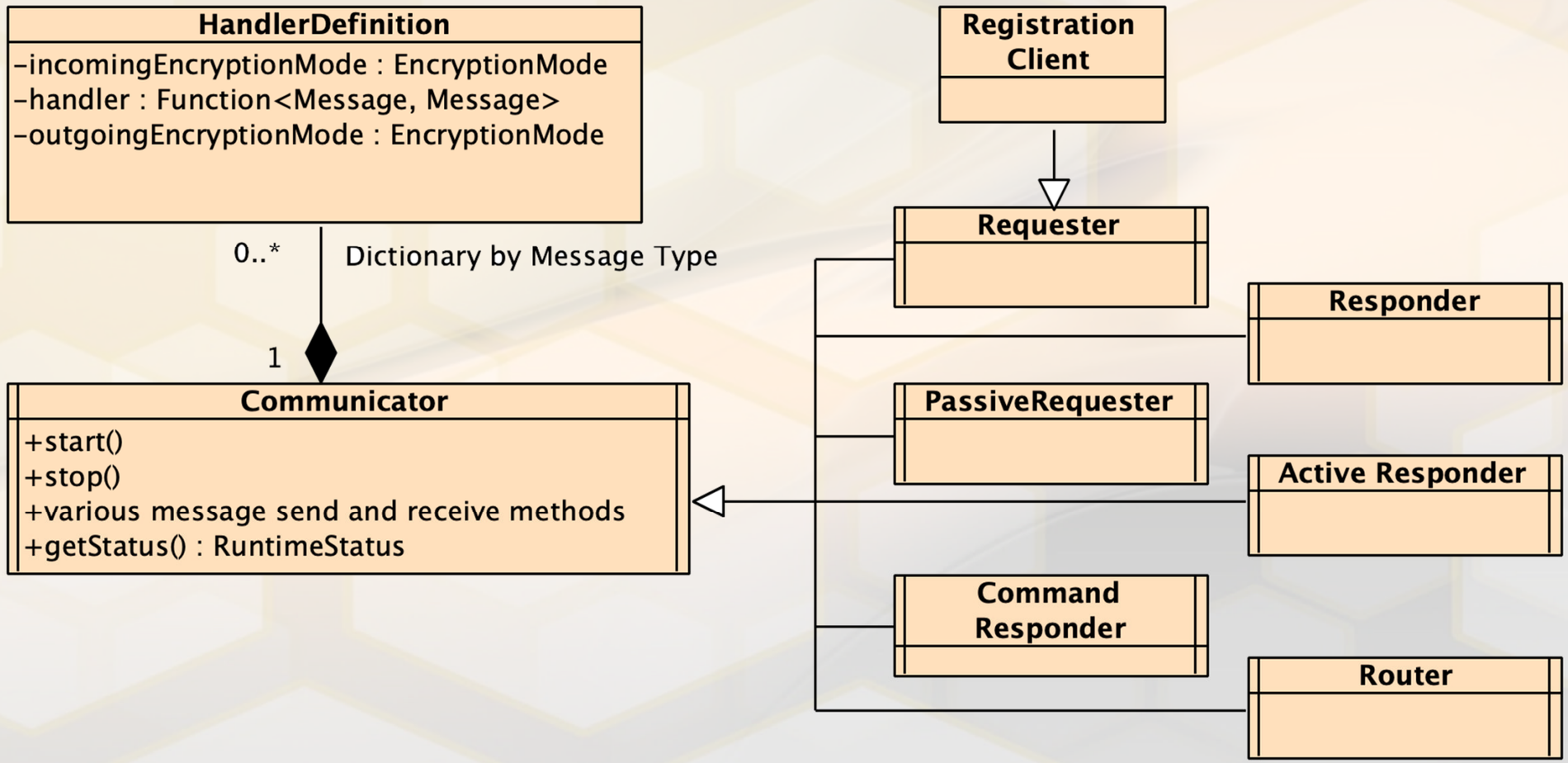
ZmqServices



JeroMF Service

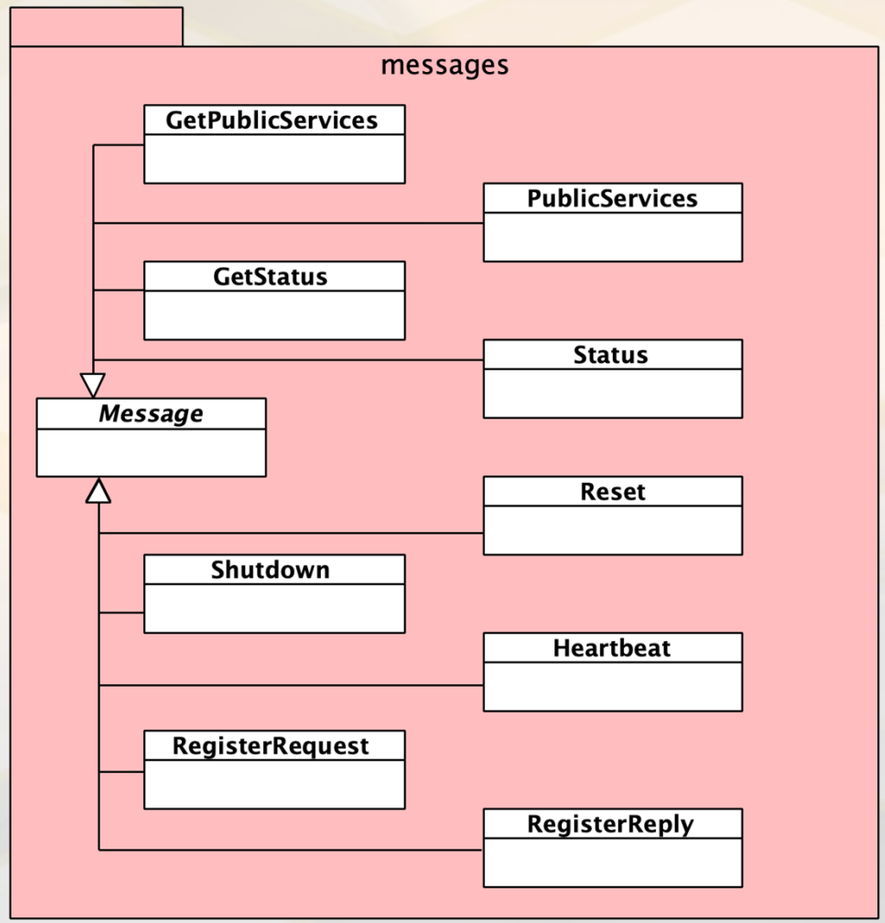
```
public class UsedCarService extends ZmqService {

 UsedCarService(Session session, String serviceName) throws ServiceException {
   super(session, serviceName);
 }

 @Override
 protected void initialize() throws ServiceException {
  super.initialize();
  apiResponder.addMessageHandler(ListCars.class,
     EncryptionMode.None,
     EncryptionMode.None,
     msg -> listCars());
  apiResponder.addMessageHandler(GetCarPrice.class,
     EncryptionMode.None,
     EncryptionMode.None,
     msg -> getCarPrice(msg));
 }

 private Message listCars(){ … }
 private Message getCarPrice(Message request){ … }
}
```

JeroMF Communicators



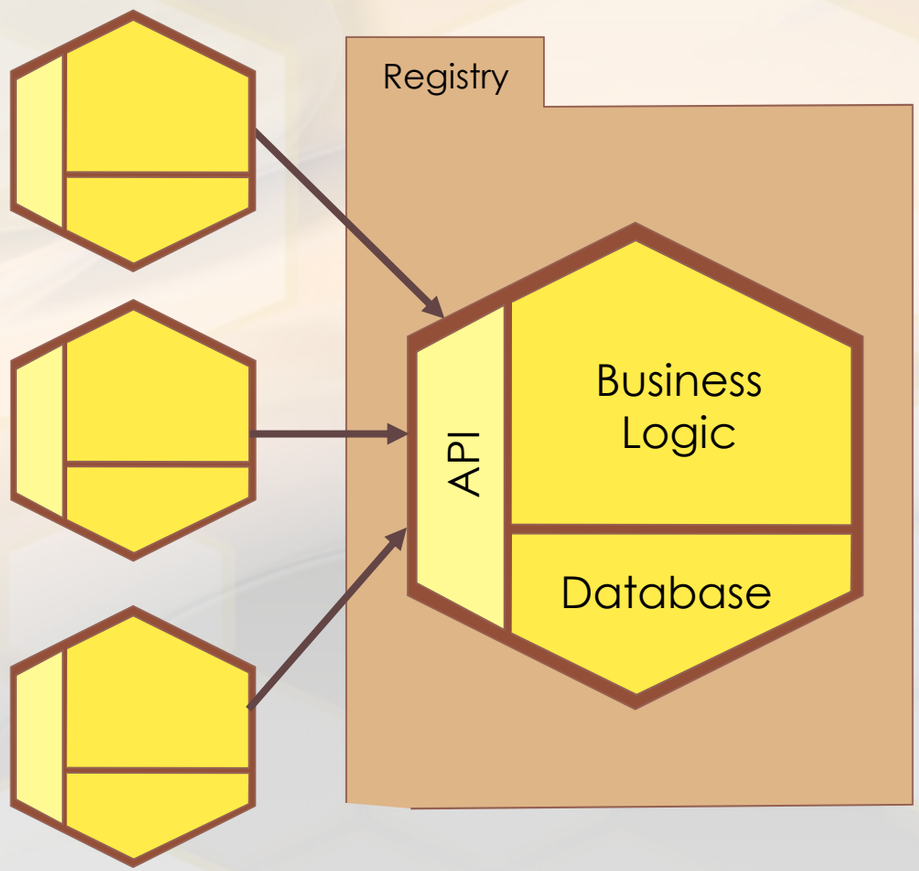
Messages

- JeroMF includes a number of standard messages
  - For registering services
  - For monitoring services
  - For system operations
- JeroMF allows developers to defined their own application specific messages by
  - Specializing *Message*
  - Defining its serialization



Service Registry

- The Registry is a JeroMF process
- It is contains a microservice with the following capabilities
  - Authenticate a service and register it with its public key and API's
  - Assign a service a symmetric key
  - Look up a service's public key
  - Look up a service's API's
- It can gracefully shutting down of a distributed application
- It can periodically require microservice's to reauthenticate
- Its use optional



Some Useful Extension Points

- JeroMF processes can contains one or more services, a custom session object, and a custom settings object.
- JeroMF services allow developers to implement all message handlers, business logic, and service synchronization through encapsulated and testable methods.
- JeroMF allows developers to create new kinds of communicators to support custom communication protocols.
- JeroMF allows developers to define and implement virtually any kind of messages

Evaluation of JeroMF Through Use in Real-world Distributed Applications

- As an initial case study, JeroMF was used to re-design and re-implement the *Sync Facility* of Utah's Child Health Advanced Record Management System.
- The Sync Facility monitor changes to various health-care database.
- When changes occur, dependent on the type of change, it may
  - Add or update a child identities in CHARM
  - Cause the re-matching of records across all connected databases
  - Generate or recall alerts
  - Publish changes and alerts to various data consumers
- Its redesign, resulted in 16 different services hosted in 9 processes, not counting the registry

Evaluation of JeroMF Through Use in Real-world Distributed Applications

- The developers reported that
  - Designing the system bases on single-responsibility microservice was easy in some areas, but challenging in others.
    - Achieving tight cohesion doesn't always come naturally.
  - Each service was relative easy to implement; JeroMF took care of the distribution details.
  - Testing each service was relative easy, since only the setup and business logic needed to be tested.
  - The reliability provided by the new Sync Facility is better than in the old version.
  - The security in the new Sync Facility is better than in the old version
    - The developers added service-level authentication and encrypted communications at the application level, with virtual no extra effort.
  - Deploying the new Sync facility is easier than the old version.

Future Work

- Other *BaseService* specializations to support other different messaging libraries:
  - HttpService
  - JmsService
- Extensible services that will act as request proxies and load balancers.
- Improved deployment and scalability features
- Empirical studies and qualitative analyses that will more rigorously evaluate its utility, reusability, extensibility, scalability, security, reliability, and maintainability.
- The tracking of software problem reports, time to resolution, induced errors from bug fixes, etc.

Conclusion

- So far, our experience with JeroMF has been positive
  - *BaseProcess* makes it easy to define new service containers.
  - *ZmqService* makes it easy to create custom microservices that can implement diverse and sophisticated functionality.
  - The predefined *Communicator* and *Message* classes allow developers to implement common styles of communication.
  - They also provide excellent starting points for implementing application-specific communication protocols.
  - It easy for developers to use either asymmetric or symmetric encryption.
  - The optional *Registry* process can act like a key store for the public keys of registered services, simplifying key management.
- We would welcome collaborators who would like to help refine and expand JeroMF


Questions?