

4 - Architecture Modulaire et Découplage

Objectifs pédagogiques

- Comprendre les limites d'une architecture monolithique
- Appliquer les principes SOLID (notamment DIP et OCP)
- Mettre en place un système d'événements avec Spring Events
- Utiliser les design patterns : Strategy, Observer, Factory
- Introduire la notion de modules/packages par domaine métier
- Tester les composants découplés

Contexte : User Story

US-042 : Notification email lors de la création d'une commande

En tant que client **Je veux** recevoir un email récapitulatif immédiatement après avoir passé une commande **Afin d'**avoir une confirmation et les détails de ma commande



Critères d'acceptation :

- Email envoyé automatiquement lors de la création d'une commande
- Email contient : numéro de commande, liste des produits, montant total
- La création de commande ne doit pas échouer si l'envoi d'email échoue
- Le système doit être extensible pour ajouter d'autres notifications (SMS, push...)
- Logs de toutes les notifications envoyées

Partie 0 : État des lieux - Le piège du couplage fort (20min)

0.1 Implémentation naïve (anti-pattern)



NE PAS FAIRE - Exemple de mauvaise pratique

```
@Service
class OrderService(
    private val orderRepository: OrderRepository,
    private val productRepository: ProductRepository,
    private val userRepository: UserRepository,
    private val mailSender: JavaMailSender // [] Dépendance directe
) {
    private val logger = LoggerFactory.getLogger(javaClass)
    @Transactional
    fun createOrder(dto: CreateOrderDto): Order {
        // 1. Validation et création
        val user = userRepository.findById(dto.userId)
```

```

        .orElseThrow { UserNotFoundException(dto.userId) }
    val order = Order(user = user)
    dto.items.forEach { itemDto ->
        val product = productRepository.findById(itemDto.productId)
            .orElseThrow { ProductNotFoundException(itemDto.productId) }
        if (product.stock < itemDto.quantity) {
            throw InsufficientStockException(product.id!!)
        }
        product.decreaseStock(itemDto.quantity)
        order.addItem(OrderItem(
            product = product,
            quantity = itemDto.quantity,
            unitPrice = product.price
        ))
    }
    val savedOrder = orderRepository.save(order)
    // □ PROBLÈME 1 : Logique métier mélangée avec l'envoi d'email
    // □ PROBLÈME 2 : Si l'email échoue, la transaction est rollback
    // □ PROBLÈME 3 : Impossible de tester la création sans email
    // □ PROBLÈME 4 : Pour ajouter SMS, il faut modifier cette classe
    try {
        sendOrderConfirmationEmail(savedOrder)
    } catch (e: Exception) {
        logger.error("Failed to send email for order ${savedOrder.id}", e)
        // Que faire ? Rollback ? Continuer ?
    }
    return savedOrder
}
private fun sendOrderConfirmationEmail(order: Order) {
    val message = mailSender.createMimeMessage()
    val helper = MimeMessageHelper(message, true, "UTF-8")
    helper.setTo(order.user.email)
    helper.setSubject("Order Confirmation #${order.id}")
    helper.setText(buildEmailContent(order), true)
    mailSender.send(message)
    logger.info("Email sent for order ${order.id}")
}
private fun buildEmailContent(order: Order): String {
    return ""
        <html>
            <body>
                <h1>Order Confirmation</h1>
                <p>Order ID: ${order.id}</p>
                <p>Total: €${order.totalAmount}</p>
            </body>
        </html>
        """.trimIndent()
}
}

```

0.2 Problèmes identifiés



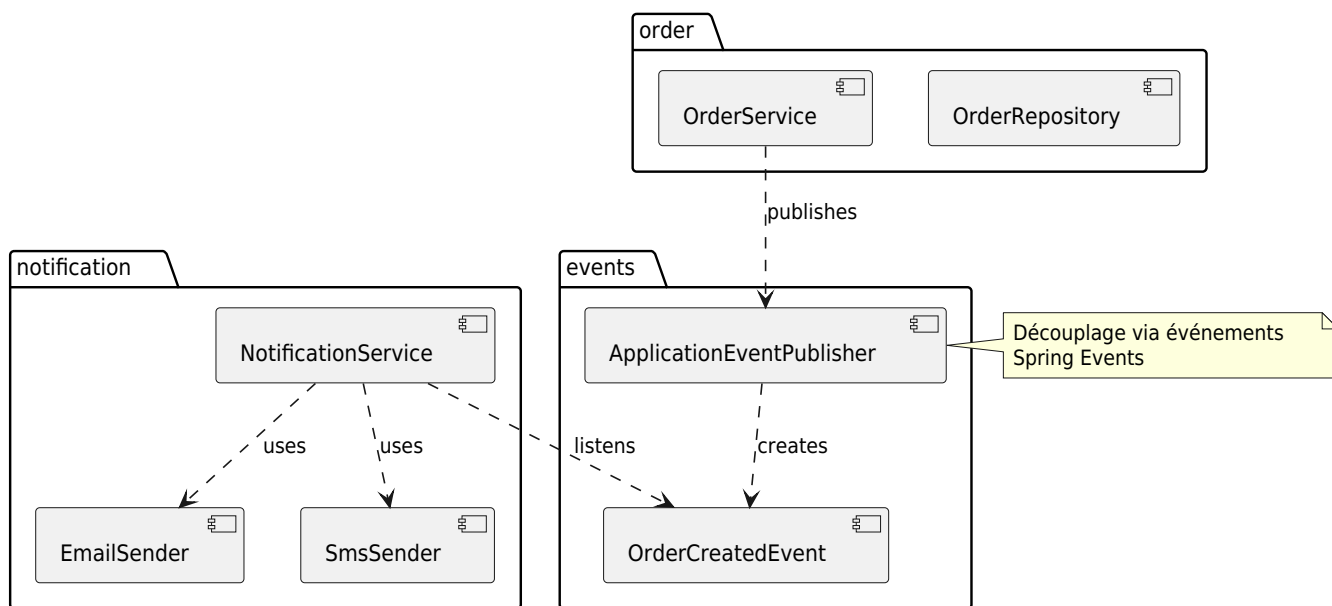
Problèmes de cette implémentation :



- Violation du Single Responsibility Principle
- Couplage fort entre domaines métier (Order ↔ Email)
- Testabilité compromise
- Gestion d'erreur problématique (transaction vs notification)
- Extensibilité limitée (ajout SMS, push...)
- Performance (envoi synchrone bloquant)

0.3 Objectif de la séance

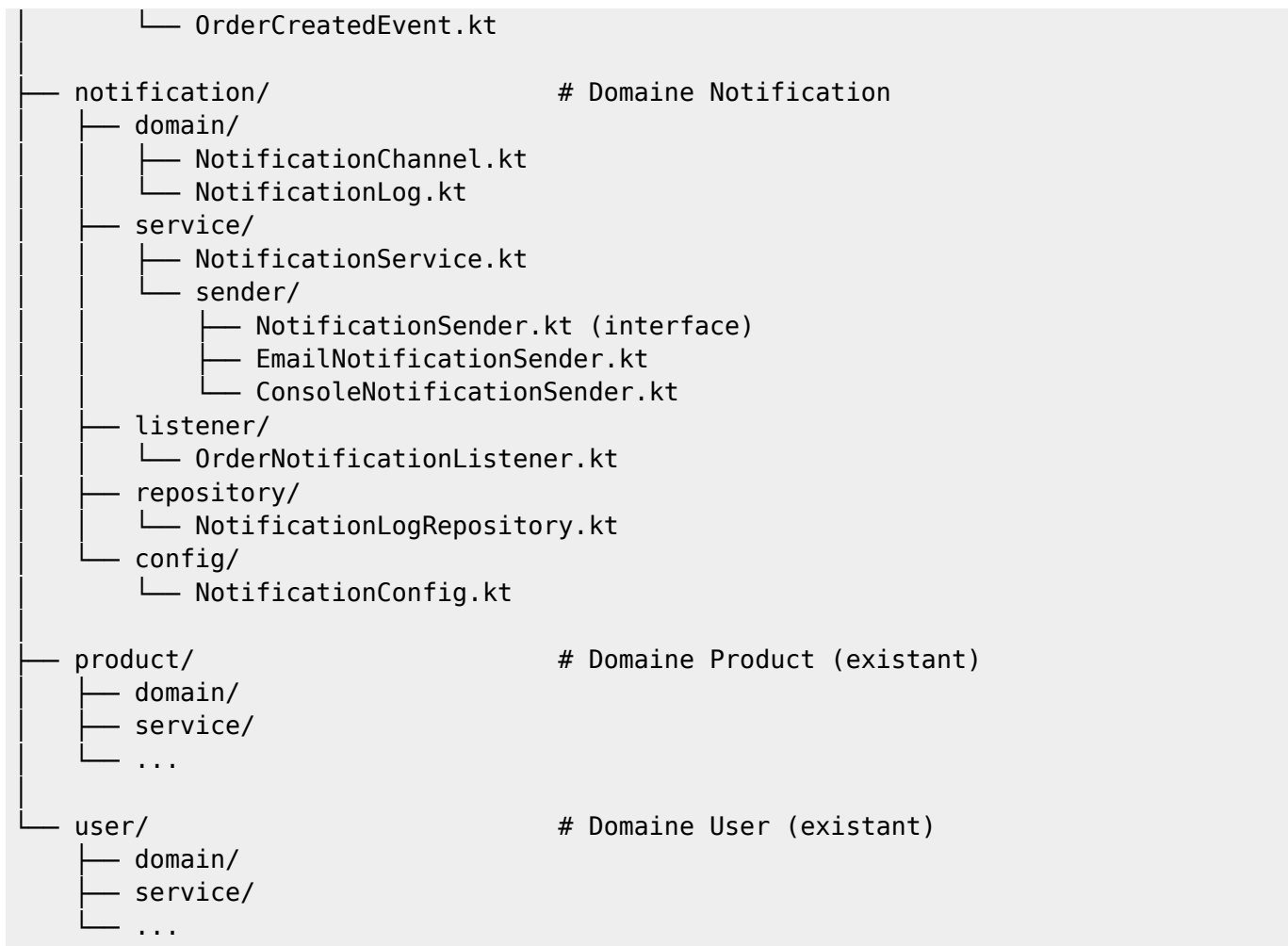
Transformer cette architecture monolithique en une architecture modulaire et découplée



Partie 1 : Réorganisation en packages par domaine (30min)

1.1 Structure modulaire proposée

```
src/main/kotlin/com/ecommerce/
├── order/                               # Domaine Order
│   ├── domain/
│   │   ├── Order.kt
│   │   ├── OrderItem.kt
│   │   └── OrderStatus.kt
│   ├── dto/
│   │   ├── CreateOrderDto.kt
│   │   └── OrderResponseDto.kt
│   ├── repository/
│   │   └── OrderRepository.kt
│   ├── service/
│   │   └── OrderService.kt
│   ├── controller/
│   │   └── OrderController.kt
│   └── event/
```



Principe de packaging par domaine (DDD-lite) :



- Chaque package = un domaine métier cohérent
- Limite les dépendances croisées
- Facilite l'extraction future en microservices
- Améliore la lisibilité et la maintenabilité

1.2 Exercice de refactoring

Exercice 1 (20min) :

Réorganiser votre code existant selon cette structure :



- Déplacer les classes Order* vers com.ecommerce.order.*
- Déplacer les classes Product* vers com.ecommerce.product.*
- Déplacer les classes User* vers com.ecommerce.user.*
- Corriger les imports
- Vérifier que tous les tests passent après refactoring

Validation :

- mvn clean verify passe au vert
- Aucune dépendance cyclique entre packages



- Les contrôleurs importent uniquement les services de leur domaine

Partie 2 : Spring Events pour le découplage (1h)

2.1 Création de l'événement métier

```
package com.ecommerce.order.event

import org.springframework.context.ApplicationEvent
import java.math.BigDecimal
import java.time.Instant
import java.util.*

/**
 * Événement publié lors de la création d'une commande
 */
class OrderCreatedEvent(
    source: Any,
    val orderId: UUID,
    val userId: UUID,
    val userEmail: String,
    val totalAmount: BigDecimal,
    val items: List<OrderItemInfo>,
    val createdAt: Instant = Instant.now()
) : ApplicationEvent(source) {
    data class OrderItemInfo(
        val productName: String,
        val quantity: Int,
        val unitPrice: BigDecimal
    )
}
```

2.2 Publication de l'événement dans OrderService

```
package com.ecommerce.order.service

import com.ecommerce.order.domain.Order
import com.ecommerce.order.domain.OrderItem
import com.ecommerce.order.dto.CreateOrderDto
import com.ecommerce.order.event.OrderCreatedEvent
import com.ecommerce.order.repository.OrderRepository
import com.ecommerce.product.repository.ProductRepository
import com.ecommerce.user.repository.UserRepository
import com.ecommerce.exception.*
import org.slf4j.LoggerFactory
import org.springframework.context.ApplicationEventPublisher
import org.springframework.stereotype.Service
```

```
import org.springframework.transaction.annotation.Transactional
import java.util.*

@Service
class OrderService(
    private val orderRepository: OrderRepository,
    private val productRepository: ProductRepository,
    private val userRepository: UserRepository,
    private val eventPublisher: ApplicationEventPublisher // Injection de l'event
publisher
) {
    private val logger = LoggerFactory.getLogger(javaClass)
    @Transactional
    fun createOrder(dto: CreateOrderDto): Order {
        logger.info("Creating order for user ${dto.userId}")
        // 1. Validation
        val user = userRepository.findById(dto.userId)
            .orElseThrow { UserNotFoundException(dto.userId) }
        require(dto.items.isNotEmpty()) {
            "Order must contain at least one item"
        }
        // 2. Création de la commande
        val order = Order(user = user)
        dto.items.forEach { itemDto ->
            val product = productRepository.findById(itemDto.productId)
                .orElseThrow { ProductNotFoundException(itemDto.productId) }
            if (product.stock < itemDto.quantity) {
                throw InsufficientStockException(product.id!!)
            }
            product.decreaseStock(itemDto.quantity)
            order.addItem(OrderItem(
                product = product,
                quantity = itemDto.quantity,
                unitPrice = product.price
            ))
        }
        // 3. Sauvegarde
        val savedOrder = orderRepository.save(order)
        logger.info("Order ${savedOrder.id} created successfully")
        // 4. Publication de l'événement
        // APRÈS le commit de la transaction (voir @TransactionalEventListener)
        val event = OrderCreatedEvent(
            source = this,
            orderId = savedOrder.id!!,
            userId = user.id!!,
            userEmail = user.email,
            totalAmount = savedOrder.totalAmount,
            items = savedOrder.items.map { item ->
                OrderCreatedEvent.OrderItemInfo(
                    productName = item.product.name,
                    quantity = item.quantity,
                    unitPrice = item.unitPrice
                )
            }
        )
        eventPublisher.publishEvent(event)
    }
}
```

```

        logger.info("OrderCreatedEvent published for order ${savedOrder.id}")
        return savedOrder
    }
    fun getOrder(orderId: UUID): Order {
        return orderRepository.findById(orderId)
            .orElseThrow { OrderNotFoundException(orderId) }
    }
    fun getUserOrders(userId: UUID): List<Order> {
        return orderRepository.findById(userId)
    }
}

```

2.3 Avantages de cette approche

Bénéfices du découplage par événements :



- OrderService n'a aucune dépendance vers notification
- Transaction commit AVANT le traitement de l'événement
- Si l'email échoue, la commande reste créée
- Testable indépendamment
- Extensible : ajout de listeners sans modifier OrderService
- Respect du principe Open/Closed (SOLID)

Partie 3 : Pattern Strategy pour les canaux de notification (1h)

4. Diagramme UML du Pattern Strategy

```

@startuml
interface NotificationSender <<Strategy>> {
    + send(recipient, subject, content)
    + getSupportedChannel(): NotificationChannel
    + isAvailable(): Boolean
}
class EmailNotificationSender <<ConcreteStrategy>> {
    - mailSender: JavaMailSender
    + send()
    + getSupportedChannel(): EMAIL
}
class ConsoleNotificationSender <<ConcreteStrategy>> {
    + send()
    + getSupportedChannel(): EMAIL
}
class SmsNotificationSender <<ConcreteStrategy>> {
    + send()
    + getSupportedChannel(): SMS
}
class NotificationService <<Context>> {

```

```

- senders: List<NotificationSender>
+ sendNotification(channel, ...)
}
NotificationSender <|.. EmailNotificationSender
NotificationSender <|.. ConsoleNotificationSender
NotificationSender <|.. SmsNotificationSender
NotificationService o--> "0..*" NotificationSender : uses
note right of NotificationService
    Le Context choisit dynamiquement
    la bonne stratégie selon le canal
Strategy Pattern + Factory Pattern
(injection automatique Spring)
end note
note bottom of NotificationSender
    Interface commune pour
    tous les algorithmes d'envoi
end note
@enduml

```

3.1 Interface NotificationSender

```

package com.ecommerce.notification.service.sender

import com.ecommerce.notification.domain.NotificationChannel

/**
 * Contrat pour l'envoi de notifications
 * Pattern Strategy
 */
interface NotificationSender {
    /**
     * Envoie une notification
     * @param recipient Destinataire (email, numéro de téléphone...)
     * @param subject Sujet de la notification
     * @param content Contenu de la notification
     */
    fun send(recipient: String, subject: String, content: String)
    /**
     * Canal supporté par cette implémentation
     */
    fun getSupportedChannel(): NotificationChannel
    /**
     * Vérifie si l'envoi est disponible
     */
    fun isAvailable(): Boolean
}

```

3.2 Implémentation Console (pour dev/test)

```

package com.ecommerce.notification.service.sender

```

```

import com.ecommerce.notification.domain.NotificationChannel
import org.slf4j.LoggerFactory
import org.springframework.boot.autoconfigure.condition.ConditionalOnProperty
import org.springframework.stereotype.Component

/**
 * Implémentation de test qui affiche les notifications dans la console
 * Activée quand notification.email.enabled=false
 */
@Component
@ConditionalOnProperty(
    name = ["notification.email.enabled"],
    havingValue = "false",
    matchIfMissing = true
)
class ConsoleNotificationSender : NotificationSender {
    private val logger = LoggerFactory.getLogger(javaClass)
    override fun send(recipient: String, subject: String, content: String) {
        logger.info("""
            □ CONSOLE EMAIL NOTIFICATION
            To: $recipient
            Subject: $subject
            $content
            """).trimIndent()
    }
    override fun getSupportedChannel() = NotificationChannel.EMAIL
    override fun isVisible() = true
}

```

3.3 Implémentation Email (pour prod)

```

package com.ecommerce.notification.service.sender

import com.ecommerce.notification.domain.NotificationChannel
import jakarta.mail.internet.MimeMessage
import org.slf4j.LoggerFactory
import org.springframework.boot.autoconfigure.condition.ConditionalOnProperty
import org.springframework.mail.javamail.JavaMailSender
import org.springframework.mail.javamail.MimeMessageHelper
import org.springframework.stereotype.Component

/**
 * Implémentation réelle avec JavaMailSender
 * Activée quand notification.email.enabled=true
 */
@Component
@ConditionalOnProperty(
    name = ["notification.email.enabled"],
    havingValue = "true"
)

```

```
)
class EmailNotificationSender(
    private val mailSender: JavaMailSender
) : NotificationSender {
    private val logger = LoggerFactory.getLogger(javaClass)
    override fun send(recipient: String, subject: String, content: String) {
        try {
            val message: MimeMessage = mailSender.createMimeMessage()
            val helper = MimeMessageHelper(message, true, "UTF-8")
            helper.setTo(recipient)
            helper.setSubject(subject)
            helper.setText(content, true) // true = HTML
            mailSender.send(message)
            logger.info("Email sent successfully to $recipient")
        } catch (e: Exception) {
            logger.error("Failed to send email to $recipient", e)
            throw RuntimeException("Email sending failed", e)
        }
    }
    override fun getSupportedChannel() = NotificationChannel.EMAIL
    override fun isAvailable(): Boolean {
        return try {
            // Vérifier si le serveur SMTP est configuré
            mailSender.createMimeMessage()
            true
        } catch (e: Exception) {
            logger.warn("Email sender is not available", e)
            false
        }
    }
}
```

3.4 NotificationService avec Pattern Factory

```
package com.ecommerce.notification.service

import com.ecommerce.notification.domain.NotificationChannel
import com.ecommerce.notification.domain.NotificationLog
import com.ecommerce.notification.repository.NotificationLogRepository
import com.ecommerce.notification.service.sender.NotificationSender
import org.slf4j.LoggerFactory
import org.springframework.stereotype.Service
import java.time.Instant

/**
 * Service de notification avec Pattern Factory
 * Sélectionne automatiquement le bon sender selon le canal
 */
@Service
class NotificationService(
    private val notificationSenders: List<NotificationSender>, // Spring injecte
    TOUS les senders
    private val logRepository: NotificationLogRepository
)
```

```
) {
    private val logger = LoggerFactory.getLogger(javaClass)
    /**
     * Envoie une notification via le canal spécifié
     */
    fun sendNotification(
        channel: NotificationChannel,
        recipient: String,
        subject: String,
        content: String
    ) {
        logger.info("Sending $channel notification to $recipient")
        // Pattern Factory : sélectionner le bon sender
        val sender = notificationSenders.firstOrNull {
            it.getSupportedChannel() == channel
        } ?: run {
            logger.error("No sender found for channel $channel")
            logFailure(channel, recipient, subject, "No sender available for this
channel")
            return
        }
        // Vérifier la disponibilité
        if (!sender.isAvailable()) {
            logger.warn("Sender for $channel is not available")
            logFailure(channel, recipient, subject, "Sender unavailable")
            return
        }
        // Envoi
        try {
            sender.send(recipient, subject, content)
            logSuccess(channel, recipient, subject)
        } catch (e: Exception) {
            logger.error("Failed to send $channel notification to $recipient", e)
            logFailure(channel, recipient, subject, e.message ?: "Unknown error")
        }
    }
    private fun logSuccess(
        channel: NotificationChannel,
        recipient: String,
        subject: String
    ) {
        val log = NotificationLog(
            channel = channel,
            recipient = recipient,
            subject = subject,
            status = "SUCCESS",
            errorMessage = null,
            sentAt = Instant.now()
        )
        logRepository.save(log)
    }
    private fun logFailure(
        channel: NotificationChannel,
        recipient: String,
        subject: String,
        errorMessage: String
```

```
) {
    val log = NotificationLog(
        channel = channel,
        recipient = recipient,
        subject = subject,
        status = "FAILED",
        errorMessage = errorMessage,
        sentAt = Instant.now()
    )
    logRepository.save(log)
}
/**
 * Récupère l'historique des notifications pour un destinataire
 */
fun getNotificationHistory(recipient: String): List<NotificationLog> {
    return logRepository.findByRecipientOrderBySentAtDesc(recipient)
}
}
```

3.5 Entité NotificationLog

```
package com.ecommerce.notification.domain

import jakarta.persistence.*
import java.time.Instant
import java.util.*

@Entity
@Table(name = "notification_logs")
class NotificationLog(
    @Id
    @GeneratedValue(strategy = GenerationType.UUID)
    var id: UUID? = null,
    @Enumerated(EnumType.STRING)
    @Column(nullable = false)
    val channel: NotificationChannel,
    @Column(nullable = false)
    val recipient: String,
    @Column(nullable = false)
    val subject: String,
    @Column(nullable = false)
    val status: String, // SUCCESS, FAILED
    @Column(length = 1000)
    val errorMessage: String?,
    @Column(nullable = false)
    val sentAt: Instant
)

enum class NotificationChannel {
    EMAIL,
    SMS,
    PUSH
}
```

```
package com.ecommerce.notification.repository

import com.ecommerce.notification.domain.NotificationLog
import org.springframework.data.jpa.repository.JpaRepository
import org.springframework.stereotype.Repository
import java.util.*

@Repository
interface NotificationLogRepository : JpaRepository<NotificationLog, UUID> {
    fun findByRecipientOrderBySentAtDesc(recipient: String): List<NotificationLog>
}
```

Partie 4 : Listener d'événements (30min)

4.1 OrderNotificationListener

```
package com.ecommerce.notification.listener

import com.ecommerce.notification.domain.NotificationChannel
import com.ecommerce.notification.service.NotificationService
import com.ecommerce.order.event.OrderCreatedEvent
import org.slf4j.LoggerFactory
import org.springframework.scheduling.annotation.Async
import org.springframework.stereotype.Component
import org.springframework.transaction.event.TransactionalEventListener
import org.springframework.transaction.event.TransactionPhase
import java.math.BigDecimal

/**
 * Écoute les événements OrderCreatedEvent et envoie des notifications
 *
 * @TransactionalEventListener : attend le COMMIT de la transaction
 * @Async : traitement asynchrone (ne bloque pas la réponse HTTP)
 */
@Component
class OrderNotificationListener(
    private val notificationService: NotificationService
) {
    private val logger = LoggerFactory.getLogger(javaClass)
    /**
     * Gère l'événement de création de commande
     * Phase AFTER_COMMIT : exécuté APRÈS le commit de la transaction
     */
    @Async
    @TransactionalEventListener(phase = TransactionPhase.AFTER_COMMIT)
    fun handleOrderCreated(event: OrderCreatedEvent) {
        logger.info("Received OrderCreatedEvent for order ${event.orderId}")
        try {
```

```

        // Envoi de la notification email
        notificationService.sendNotification(
            channel = NotificationChannel.EMAIL,
            recipient = event.userEmail,
            subject = "Order Confirmation #${event.orderId}",
            content = buildEmailContent(event)
        )
    } catch (e: Exception) {
        // Si l'email échoue, la commande reste créée
        logger.error("Failed to send notification for order ${event.orderId}",
e)
    }
}
private fun buildEmailContent(event: OrderCreatedEvent): String {
    val html = StringBuilder()
    html.append("<!DOCTYPE html>")
    html.append("<html><head><meta charset='UTF-8'></head><body>")
    html.append("<h1>Order Confirmation</h1>")
    html.append("<p>Thank you for your order!</p>")
    html.append("<p><strong>Order ID:</strong> ${event.orderId}</p>")
    html.append("<p><strong>Order Date:</strong> ${event.createdAt}</p>")
    html.append("<h2>Order Details</h2>")
    html.append("<table border='1' cellpadding='10' cellspacing='0'>")
    html.append("<tr><th>Product</th><th>Quantity</th><th>Unit
Price</th><th>Total</th></tr>")
    event.items.forEach { item ->
        val itemTotal = item.unitPrice.multiply(BigDecimal(item.quantity))
        html.append("<tr>")
        html.append("<td>${item.productName}</td>")
        html.append("<td>${item.quantity}</td>")
        html.append("<td>€${item.unitPrice}</td>")
        html.append("<td>€$itemTotal</td>")
        html.append("</tr>")
    }
    html.append("</table>")
    html.append("<p><strong>Total Amount: €${event.totalAmount}</strong></p>")
    html.append("<p>Thank you for your order!</p>")
    html.append("</body></html>")
    return html.toString()
}
}
}

```

4.2 Configuration pour @Async

```

package com.ecommerce.notification.config

import org.springframework.context.annotation.Configuration
import org.springframework.scheduling.annotation.EnableAsync

@Configuration
@EnableAsync
class NotificationConfig {
    // Configuration par défaut de Spring pour @Async
}

```

```
// Un ThreadPoolTaskExecutor sera créé automatiquement  
}
```

4.3 Configuration des propriétés

```
# application-dev.properties  
notification.email.enabled=false # Console en dev  
  
# application-test.properties  
notification.email.enabled=false # Console en test  
  
# application-prod.properties  
notification.email.enabled=true # Vrai email en prod  
  
# Configuration Spring Mail (seulement si enabled=true)  
spring.mail.host=smtp.gmail.com  
spring.mail.port=587  
spring.mail.username=${SMTP_USERNAME}  
spring.mail.password=${SMTP_PASSWORD}  
spring.mail.properties.mail.smtp.auth=true  
spring.mail.properties.mail.smtp.starttls.enable=true
```

Partie 5 : Tests du système découplé (1h)

5.1 Test unitaire du NotificationService

```
package com.ecommerce.notification.service  
  
import com.ecommerce.notification.domain.NotificationChannel  
import com.ecommerce.notification.repository.NotificationLogRepository  
import com.ecommerce.notification.service.sender.NotificationSender  
import io.mockk.*  
import org.assertj.core.api.Assertions.*  
import org.junit.jupiter.api.BeforeEach  
import org.junit.jupiter.api.DisplayName  
import org.junit.jupiter.api.Test  
  
@DisplayName("NotificationService - Unit Tests")  
class NotificationServiceTest {  
    private lateinit var logRepository: NotificationLogRepository  
    private lateinit var emailSender: NotificationSender  
    private lateinit var smsSender: NotificationSender  
    private lateinit var notificationService: NotificationService  
    @BeforeEach  
    fun setUp() {  
        logRepository = mockk(relaxed = true)  
        emailSender = mockk()  
        smsSender = mockk()  
        every { emailSender.getSupportedChannel() } returns
```

```

NotificationChannel.EMAIL
    every { smsSender.getSupportedChannel() } returns NotificationChannel.SMS
    notificationService = NotificationService(
        notificationSenders = listOf(emailSender, smsSender),
        logRepository = logRepository
    )
}
@Test
@DisplayName("Should send notification when sender is available")
fun `sendNotification with available sender should send successfully`() {
    // Given
    every { emailSender.isAvailable() } returns true
    every { emailSender.send(any(), any(), any()) } just Runs
    // When
    notificationService.sendNotification(
        NotificationChannel.EMAIL,
        "test@example.com",
        "Test Subject",
        "Test Content"
    )
    // Then
    verify(exactly = 1) {
        emailSender.send("test@example.com", "Test Subject", "Test Content")
    }
    verify(exactly = 1) {
        logRepository.save(match { it.status == "SUCCESS" })
    }
}
@Test
@DisplayName("Should log failure when sender throws exception")
fun `sendNotification when sender fails should log error`() {
    // Given
    every { emailSender.isAvailable() } returns true
    every { emailSender.send(any(), any(), any()) } throws
RuntimeException("SMTP error")
    // When
    notificationService.sendNotification(
        NotificationChannel.EMAIL,
        "test@example.com",
        "Test",
        "Content"
    )
    // Then
    verify(exactly = 1) {
        logRepository.save(match {
            it.status == "FAILED" && it.errorMessage?.contains("SMTP error") ==
true
        })
    }
}
@Test
@DisplayName("Should not send when no sender for channel")
fun `sendNotification with unsupported channel should log failure`() {
    // Given
    // Pas de sender pour PUSH
    // When

```

```

notificationService.sendNotification(
    NotificationChannel.PUSH,
    "test@example.com",
    "Test",
    "Content"
)
// Then
verify(exactly = 0) {
    emailSender.send(any(), any(), any())
    smsSender.send(any(), any(), any())
}
verify(exactly = 1) {
    logRepository.save(match {
        it.status == "FAILED" &&
        it.errorMessage?.contains("No sender available") == true
    })
}
}
@Test
@DisplayName("Should not send when sender is unavailable")
fun `sendNotification when sender unavailable should log failure`() {
    // Given
    every { emailSender.isAvailable() } returns false
    // When
    notificationService.sendNotification(
        NotificationChannel.EMAIL,
        "test@example.com",
        "Test",
        "Content"
    )
    // Then
    verify(exactly = 0) { emailSender.send(anyString(), anyString(),
anyString()) }
    verify(exactly = 1) {
        logRepository.save(match {
            it.status == "FAILED" &&
            it.errorMessage?.contains("unavailable") == true
        })
    }
}
}
}

```

5.2 Test d'intégration avec capture d'événements

```

package com.ecommerce.order.controller

import com.ecommerce.order.event.OrderCreatedEvent
import org.assertj.core.api.Assertions.*
import org.junit.jupiter.api.BeforeEach
import org.junit.jupiter.api.DisplayName
import org.junit.jupiter.api.Test
import org.springframework.beans.factory.annotation.Autowired
import org.springframework.boot.test.autoconfigure.web.servlet.AutoConfigureMockMvc

```

```
import org.springframework.boot.test.context.SpringBootTest
import org.springframework.boot.test.context.TestConfiguration
import org.springframework.context.annotation.Bean
import org.springframework.context.annotation.Primary
import org.springframework.context.event.EventListener
import org.springframework.http.MediaType
import org.springframework.test.context.ActiveProfiles
import org.springframework.test.web.servlet.MockMvc
import org.springframework.test.web.servlet.post
import org.springframework.transaction.annotation.Transactional

@SpringBootTest
@AutoConfigureMockMvc
@ActiveProfiles("test")
@Transactional
@DisplayName("OrderController - Integration Tests with Events")
class OrderControllerEventIntegrationTest {
    @Autowired
    private lateinit var mockMvc: MockMvc
    @Autowired
    private lateinit var testEventListener: TestEventListener
    @BeforeEach
    fun setUp() {
        testEventListener.reset()
    }
    @Test
    @DisplayName("POST /orders should publish OrderCreatedEvent")
    fun `createOrder should publish event after successful creation`() {
        // Given
        val orderRequest = """
            {
                "userId": "${setupUserId()}",
                "items": [
                    {
                        "productId": "${setupProductId()}",
                        "quantity": 2
                    }
                ]
            }
        """.trimIndent()
        // When
        mockMvc.post("/orders") {
            contentType = MediaType.APPLICATION_JSON
            content = orderRequest
        }.andExpect {
            status { isCreated() }
        }
        // Then - Vérifier que l'événement a été publié
        Thread.sleep(500) // Attendre le traitement asynchrone
        val events = testEventListener.getReceivedEvents()
        assertThat(events).hasSize(1)
        val event = events[0]
        assertThat(event.userEmail).isNotEmpty()
        assertThat(event.totalAmount).isGreaterThan(java.math.BigDecimal.ZERO)
        assertThat(event.items).isNotEmpty()
    }
}
```

```
private fun setupUserId(): String {
    // Créer un utilisateur de test
    // TODO: implémenter
    return java.util.UUID.randomUUID().toString()
}
private fun setupProductId(): String {
    // Créer un produit de test
    // TODO: implémenter
    return java.util.UUID.randomUUID().toString()
}
/**
 * Configuration de test pour capturer les événements
 */
@TestConfiguration
class TestConfig {
    @Bean
    @Primary
    fun testEventListener(): TestEventListener {
        return TestEventListener()
    }
}
/**
 * Listener de test pour vérifier la publication d'événements
 */
class TestEventListener {
    private val receivedEvents = mutableListOf<OrderCreatedEvent>()
    @EventListener
    fun handleEvent(event: OrderCreatedEvent) {
        receivedEvents.add(event)
    }
    fun getReceivedEvents(): List<OrderCreatedEvent> = receivedEvents.toList()
    fun reset() {
        receivedEvents.clear()
    }
}
}
```

5.3 Test unitaire du Listener

```
package com.ecommerce.notification.listener

import com.ecommerce.notification.domain.NotificationChannel
import com.ecommerce.notification.service.NotificationService
import com.ecommerce.order.event.OrderCreatedEvent
import io.mockk.*
import org.junit.jupiter.api.BeforeEach
import org.junit.jupiter.api.DisplayName
import org.junit.jupiter.api.Test
import java.math.BigDecimal
import java.util.*

@DisplayName("OrderNotificationListener - Unit Tests")
class OrderNotificationListenerTest {
```

```
private lateinit var notificationService: NotificationService
private lateinit var listener: OrderNotificationListener
@BeforeEach
fun setUp() {
    notificationService = mockk(relaxed = true)
    listener = OrderNotificationListener(notificationService)
}
@Test
@DisplayName("Should send email notification when order is created")
fun `handleOrderCreated should send email notification`() {
    // Given
    val event = OrderCreatedEvent(
        source = this,
        orderId = UUID.randomUUID(),
        userId = UUID.randomUUID(),
        userEmail = "customer@example.com",
        totalAmount = BigDecimal.valueOf(100.00),
        items = emptyList()
    )
    // When
    listener.handleOrderCreated(event)
    // Then
    verify(exactly = 1) {
        notificationService.sendNotification(
            NotificationChannel.EMAIL,
            "customer@example.com",
            match { it.contains("Order Confirmation") },
            any()
        )
    }
}
@Test
@DisplayName("Should include order details in email content")
fun `handleOrderCreated should include all order information`() {
    // Given
    val orderId = UUID.randomUUID()
    val event = OrderCreatedEvent(
        source = this,
        orderId = orderId,
        userId = UUID.randomUUID(),
        userEmail = "customer@example.com",
        totalAmount = BigDecimal("250.00"),
        items = listOf(
            OrderCreatedEvent.OrderItemInfo("Product A", 2,
                BigDecimal("100.00")),
            OrderCreatedEvent.OrderItemInfo("Product B", 1,
                BigDecimal("50.00"))
        )
    )
    // When
    listener.handleOrderCreated(event)
    // Then
    verify {
        notificationService.sendNotification(
            NotificationChannel.EMAIL,
            "customer@example.com",
```

```
        any(),
        match { content ->
            content.contains(orderId.toString()) &&
            content.contains("Product A") &&
            content.contains("Product B") &&
            content.contains("250.00")
        }
    )
}
}
```

Exercice 2 (45min) :

Compléter la suite de tests :



- Test du ConsoleNotificationSender
- Test d'intégration complet : création commande → vérification log notification
- Test de gestion d'erreur : email invalide
- Test de performance : vérifier que l'envoi est bien asynchrone (temps de réponse < 500ms)

Validation :

- Tous les tests passent
- Couverture > 80% sur le package notification
- Tests asynchrones correctement gérés

Partie 6 : Extension - Ajout d'un nouveau canal (SMS) (20min - Bonus)

Challenge : Ajouter un canal SMS sans modifier le code existant (principe Open/Closed)

```
package com.ecommerce.notification.service.sender

import com.ecommerce.notification.domain.NotificationChannel
import org.slf4j.LoggerFactory
import org.springframework.boot.autoconfigure.condition.ConditionalOnProperty
import org.springframework.stereotype.Component

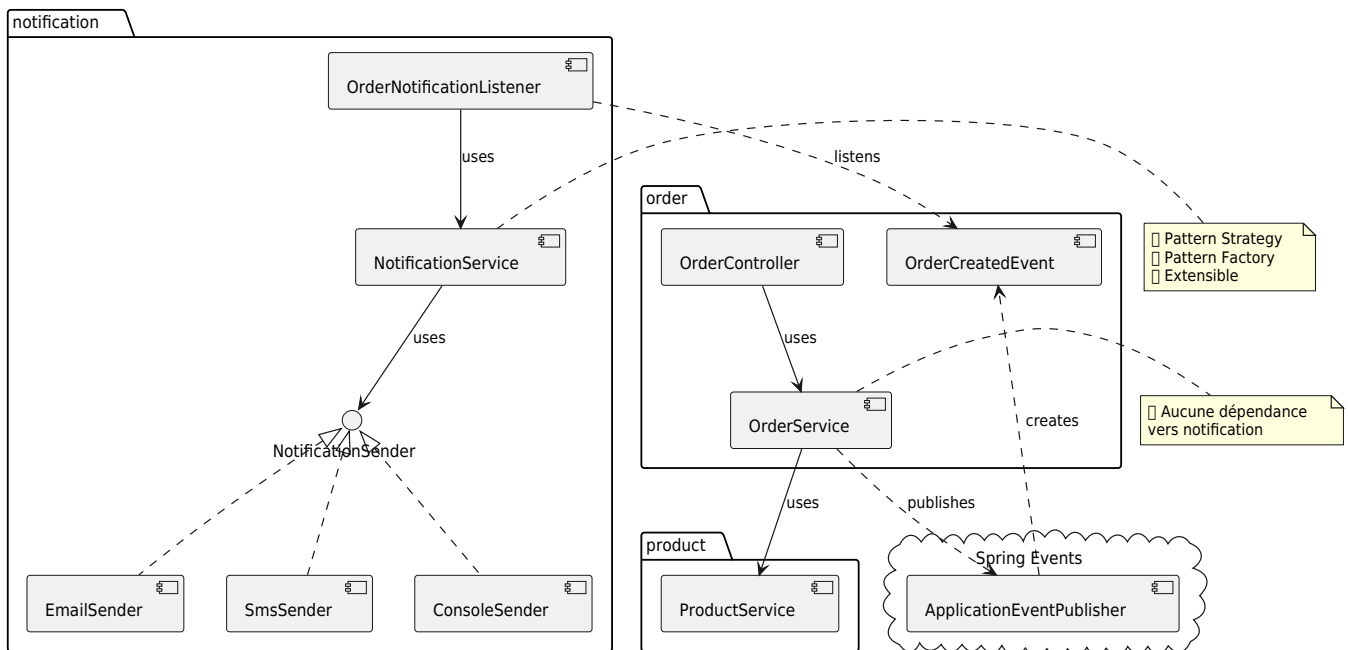
@Component
@ConditionalOnProperty(
    name = ["notification.sms.enabled"],
    havingValue = "true"
)
class SmsNotificationSender : NotificationSender {
    private val logger = LoggerFactory.getLogger(javaClass)
    override fun send(recipient: String, subject: String, content: String) {
        // Intégration avec Twilio, AWS SNS, etc.
        logger.info("Sending SMS to $recipient: $content")
    }
}
```

```
// Implémentation simplifiée pour la demo  
}  
override fun getSupportedChannel() = NotificationChannel.SMS  
override fun isAvailable() = true  
}
```

Points à noter :

- Aucune modification dans NotificationService
- Spring injecte automatiquement le nouveau sender
- Activation via configuration (notification.sms.enabled)

Récapitulatif : Architecture finale



Livrables attendus

Priorités (4h)

Architecture modulaire (30min) :

- Packages réorganisés par domaine (order, notification, product, user)
- Pas de dépendances cycliques
- Tests passent après refactoring



Système de notification (2h) :

- OrderCreatedEvent implémenté
- Publication d'événement dans OrderService
- Interface NotificationSender + 2 implémentations (Console + Email)
- NotificationService avec Pattern Factory
- OrderNotificationListener avec @TransactionalEventListener
- Entité NotificationLog pour audit

- Configuration multi-environnements

Tests (1h) :

- Tests unitaires de `NotificationService`
- Tests unitaires de `OrderNotificationListener`
- Test d'intégration avec capture d'événements
- Vérification que l'envoi est asynchrone
- Couverture > 70% sur le package notification



Documentation (30min) :

- Diagramme d'architecture dans le README
- Documentation des patterns utilisés
- Guide de configuration des notifications

Bonus (si temps)

- Ajout du canal SMS
- Template d'email avec Thymeleaf
- Retry automatique en cas d'échec
- Dashboard des notifications dans H2 console
- Métriques Prometheus (nombre d'emails envoyés)

Concepts clés à retenir

Design Patterns appliqués

- **Observer** : Spring Events pour la communication inter-domaines
- **Strategy** : `NotificationSender` avec différentes implémentations
- **Factory** : Injection automatique de tous les senders
- **Dependency Inversion** : `OrderService` ne dépend que d'abstractions

Principes SOLID



- **Single Responsibility** : chaque service a une responsabilité unique
- **Open/Closed** : ajout de canaux sans modifier le code existant
- **Liskov Substitution** : toutes les implémentations respectent le contrat
- **Interface Segregation** : interface minimale `NotificationSender`
- **Dependency Inversion** : dépendances vers abstractions, pas implémentations

Architecture

- **Packaging par domaine** : prépare la transition vers les microservices
- **Event-driven** : découplage temporel et organisationnel
- **Async processing** : performances et résilience
- **Configuration externalisée** : flexibilité environnements

Ressources

- [Spring Events Documentation](#)

- [Refactoring Guru - Design Patterns](#)
- [Martin Fowler - Event-Driven Architecture](#)
- [Baeldung - Spring Events](#)
- [Spring @Async Documentation](#)
- [MockK Documentation](#)
- [Kotlin Data Classes](#)

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