Perfect 👍 thanks for confirming. Since we finished **16. Performance Optimization in Node.js**, let's now move on in sequence.

Here's the full content for:

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17. Microservices & Message Queues

Microservices architecture is a way of designing applications as a collection of small, independent services communicating via lightweight mechanisms (often HTTP or message queues). Node.js is well-suited for building microservices due to its **non-blocking, event-driven architecture**.

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1. What are Microservices?

- **Monolith**: Entire app in a single codebase → tightly coupled.
- **Microservices**: App is divided into small services → loosely coupled, independently deployable.
- Each service owns its **data** and **logic**.
- Communication happens via:
    - **REST APIs** (synchronous)
    - **Message Queues / Pub-Sub** (asynchronous)

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2. Advantages of Microservices

- Scalability → Scale only required services.
- Independent deployment & updates.
- Technology-agnostic → Each service can be built with different languages.
- Fault isolation → Failure in one service doesn't crash the whole system.

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3. Communication Patterns

1. **Synchronous (HTTP/REST, gRPC)**
    - Direct API calls between services.
    - Fast but tightly coupled.
2. **Asynchronous (Message Queues, Pub/Sub)**
    - Decoupled, reliable communication.
    - Services publish/subscribe to events or send messages via brokers.

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4. Message Queues in Node.js

Message queues handle **asynchronous communication** by decoupling producers (senders) and consumers (receivers).

Popular Message Queues

- **RabbitMQ** → Traditional broker, supports complex routing.
- **Kafka** → High throughput, distributed event streaming.
- **Redis Pub/Sub** → Lightweight, in-memory.
- **Bull / Bee-Queue** → Redis-based job/task queues for Node.js.

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5. Example: RabbitMQ with Node.js

📌 **Producer (send message):**

```
const amqp = require("amqplib");

async function sendMsg() {
  const connection = await amqp.connect("amqp://localhost");
  const channel = await connection.createChannel();
  const queue = "tasks";

  await channel.assertQueue(queue, { durable: true });
  channel.sendToQueue(queue, Buffer.from("Process this task"));
  console.log("Message sent");

  setTimeout(() => connection.close(), 500);
}

sendMsg();
```

📌 **Consumer (receive message):**

```
const amqp = require("amqplib");

async function receiveMsg() {
  const connection = await amqp.connect("amqp://localhost");
  const channel = await connection.createChannel();
  const queue = "tasks";

  await channel.assertQueue(queue, { durable: true });
  console.log("Waiting for messages...");

  channel.consume(queue, (msg) => {
    console.log("Received:", msg.content.toString());
    channel.ack(msg);
  });
}
```

```
receiveMsg();
```

---

6. Example: Bull Queue with Redis

```
const Queue = require("bull");

// Create queue
const jobQueue = new Queue("emailQueue", "redis://127.0.0.1:6379");

// Producer
jobQueue.add({ email: "user@example.com" });

// Consumer
jobQueue.process(async (job) => {
  console.log("Sending email to:", job.data.email);
});
```

---

7. When to Use Message Queues?

- ✔ Offloading heavy/long tasks (emails, reports).
- ✔ Event-driven systems (e.g., order placed → send invoice).
- ✔ High traffic systems (queues buffer load).
- ✔ Decoupling microservices.

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8. Interview Tips

- **Q:** Why use message queues in Node.js microservices?
  A: To decouple services, improve fault tolerance, and handle asynchronous workloads like notifications, logs, or background jobs.
- **Q:** RabbitMQ vs Kafka?
  A:
  - RabbitMQ → Reliable, supports complex routing, low latency.
  - Kafka → High throughput, distributed log-based, great for event streaming.

☑ Next up is **18. GraphQL with Node.js**

Do you want me to dive into **GraphQL basics + implementation with Apollo Server/Express** next?