EP15: What happens when you swipe a credit card? Also...

ALEX XU
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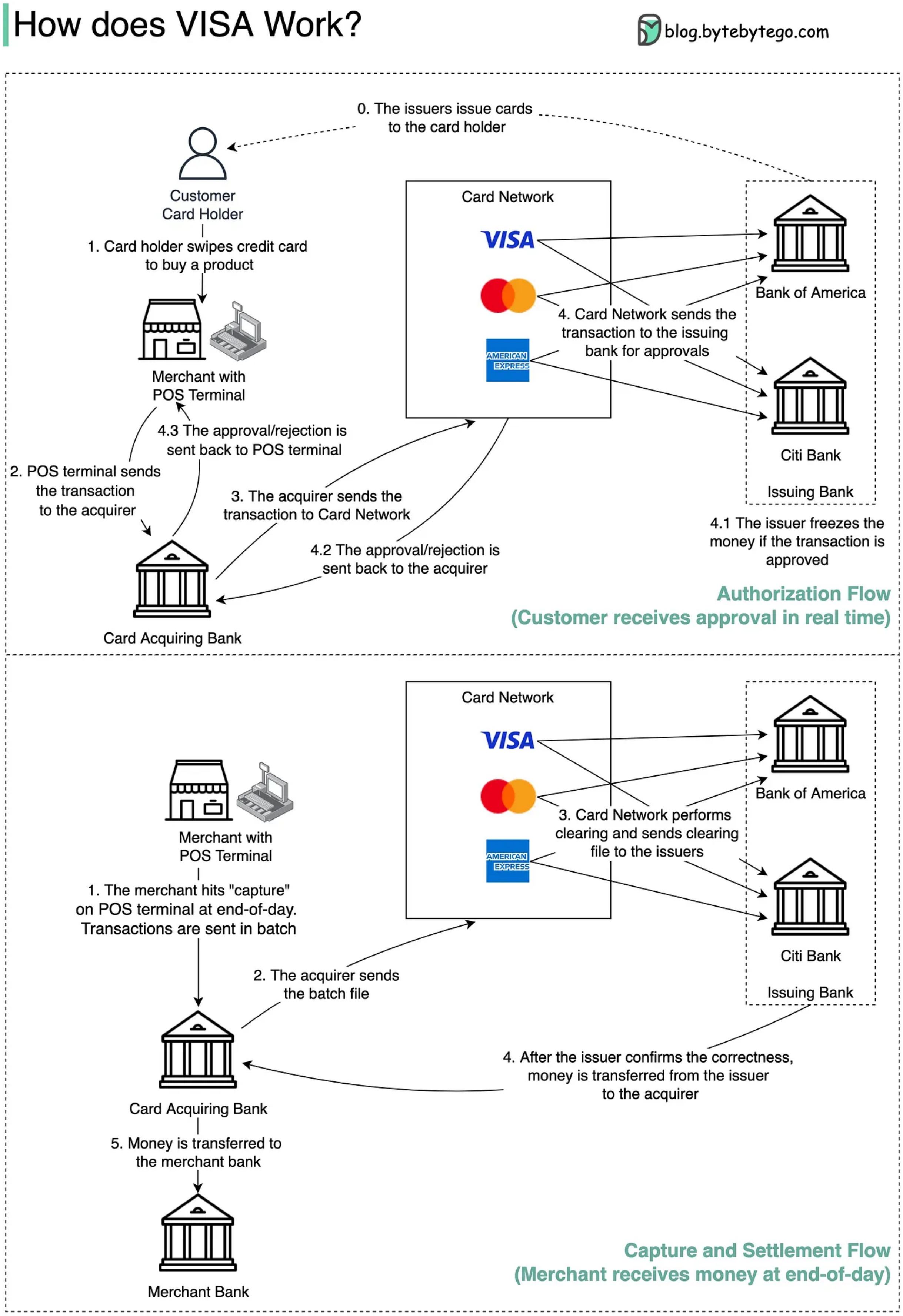
For this week's newsletter, we will cover:

- How does VISA work when we swipe a credit card at a merchant's shop?
- What are the differences between bare metal, virtual machines, and containers? (YouTube Video)
- How do you pay from your digital wallets, such as Paytm, Paypal, and Venmo, by scanning the QR code?
- Flash sale system
- System design exercise

How does VISA work when we swipe a credit card at a merchant's shop?

VISA, Mastercard, and American Express act as card networks for clearing and settling funds. The card acquiring bank and the card issuing bank can be – and often are – different. If banks were to settle transactions one by one without an intermediary, each bank would have to settle the transactions with all the other banks. This is quite inefficient.


How does VISA Work?
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0. The issuers issue cards to the card holder
Customer Card Holder
1. Card holder swipes credit card to buy a product
Merchant with POS Terminal
Card Network
VISA
AMERICAN EXPRESS
Bank of America
Citi Bank
Issuing Bank
4. Card Network sends the transaction to the issuing bank for approvals
4.3 The approval/rejection is sent back to POS terminal
2. POS terminal sends the transaction to the acquirer
3. The acquirer sends the transaction to Card Network
4.2 The approval/rejection is sent back to the acquirer
4.1 The issuer freezes the money if the transaction is approved
Card Acquiring Bank
Authorization Flow (Customer receives approval in real time)
Card Network
VISA
AMERICAN EXPRESS
Bank of America
Citi Bank
Issuing Bank
Merchant with POS Terminal
3. Card Network performs clearing and sends clearing file to the issuers
1. The merchant hits "capture" on POS terminal at end-of-day. Transactions are sent in batch
2. The acquirer sends the batch file
4. After the issuer confirms the correctness, money is transferred from the issuer to the acquirer
Card Acquiring Bank
5. Money is transferred to the merchant bank
Merchant Bank
Capture and Settlement Flow (Merchant receives money at end-of-day)

The diagram shows VISA's role in the credit card payment process. There are two flows involved. Authorization flow happens when the customer swipes the credit card. Capture and settlement flow occurs when the merchant wants to get the money at the end of the day.

- **Authorization Flow**

Step 0: The card issuing bank issues credit cards to its customers.

Step 1: The cardholder wants to buy a product and swipes the credit card at the Point of Sale (POS) terminal in the merchant's shop.

Step 2: The POS terminal sends the transaction to the acquiring bank, which has provided the POS terminal.

Steps 3 and 4: The acquiring bank sends the transaction to the card network, also called the card scheme. The card network sends the transaction to the issuing bank for approval.

Steps 4.1, 4.2, and 4.3: The issuing bank freezes the money if the transaction is approved. The approval or rejection is sent back to the acquirer, as well as the POS terminal.

- **Capture and Settlement Flow**

Steps 1 and 2: The merchant wants to collect the money at the end of the day, so they hit ”capture” on the POS terminal. The transactions are sent to the acquirer in batches. The acquirer sends the batch file with transactions to the card network.

Step 3: The card network performs clearing for the transactions collected from different acquirers, and sends the clearing files to different issuing banks.

Step 4: The issuing banks confirm the correctness of the clearing files, and transfer money to the relevant acquiring banks.

Step 5: The acquiring bank then transfers money to the merchant's bank.

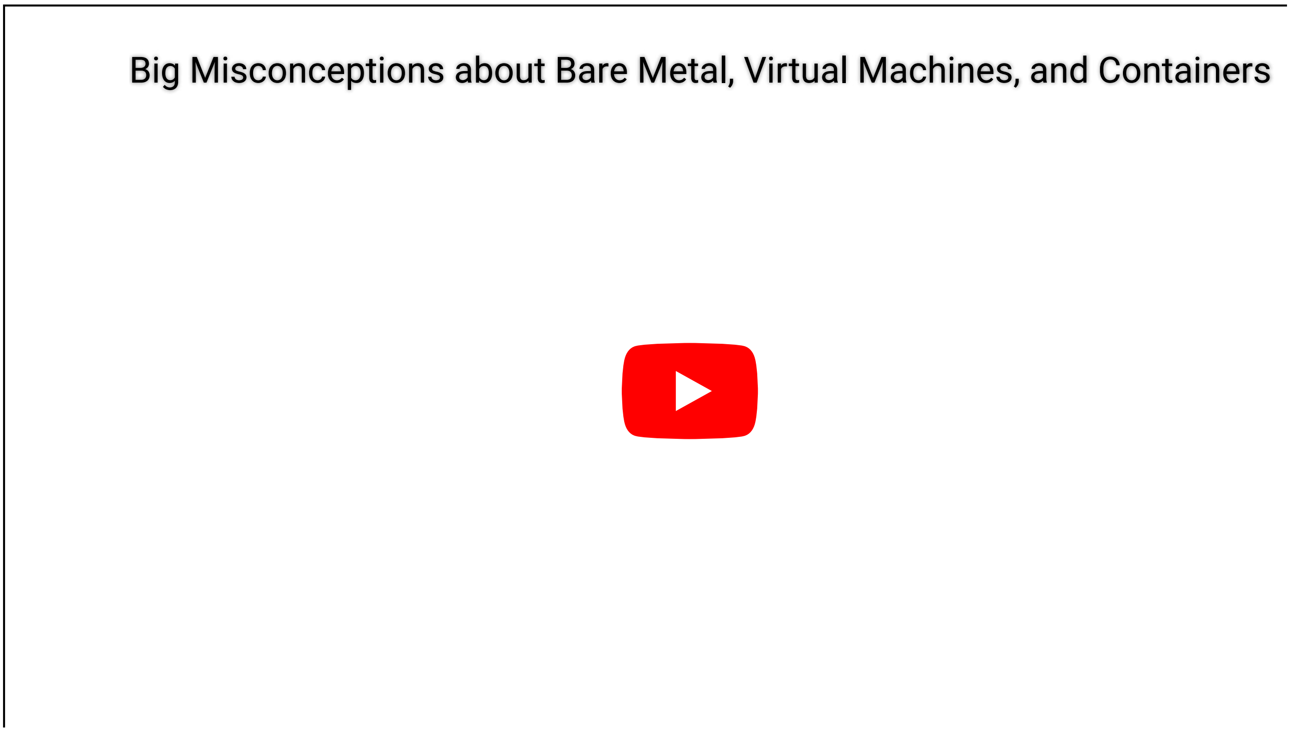
Step 4: The card network clears the transactions from different acquiring banks. Clearing is a process in which mutual offset transactions are netted, so the number of total transactions is reduced.

In the process, the card network takes on the burden of talking to each bank and receives service fees in return.

Over to you: Do you think this flow is way too complicated? What will be the future of payments in your opinion?

What are the differences between bare metal, virtual machines, and containers?

When deploying a modern application stack, how do we decide which one to use?

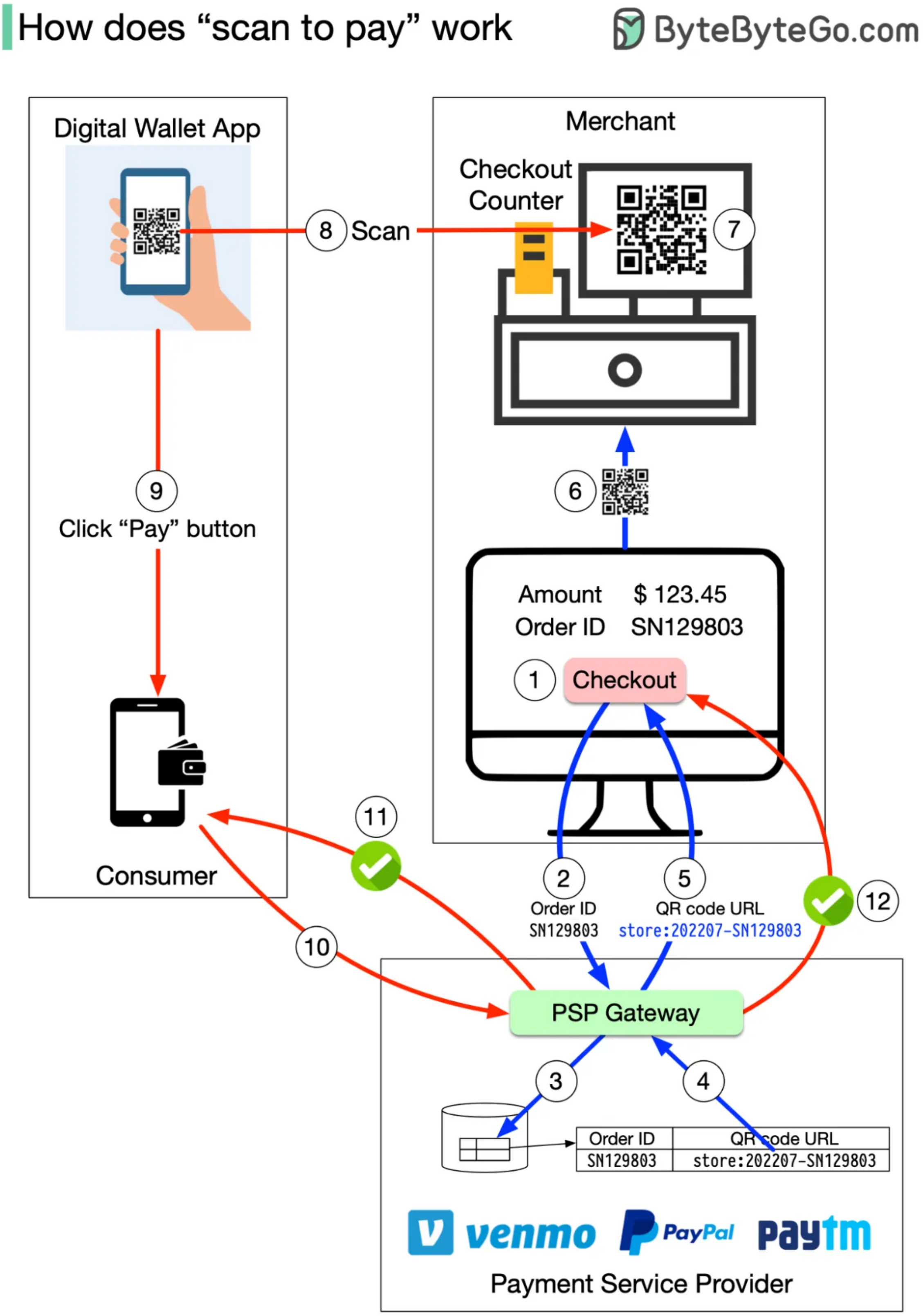


Big Misconceptions about Bare Metal, Virtual Machines, and Containers

How do you pay from your digital wallets, such as Paytm, Paypal, and Venmo, by scanning the QR code?

To understand the process involved, we need to divide the "scan to pay" process into two sub-processes:

1. Merchant generates a QR code and displays it on the screen
2. Consumer scans the QR code and pays



Here are the steps for generating the QR code:

1. When you want to pay for your shopping, the cashier tallies up all the goods and calculates the total amount due, for example, $123.45. The checkout has an order ID of SN129803. The cashier clicks the “checkout” button.
2. The cashier’s computer sends the order ID and the amount to PSP.
3. The PSP saves this information to the database and generates a QR code URL.
4. PSP’s Payment Gateway service reads the QR code URL.
5. The payment gateway returns the QR code URL to the merchant’s computer.
6. The merchant’s computer sends the QR code URL (or image) to the checkout counter.
7. The checkout counter displays the QR code.

These 7 steps are completed in less than a second. Now it’s the consumer’s turn to pay from their digital wallet by scanning the QR code:

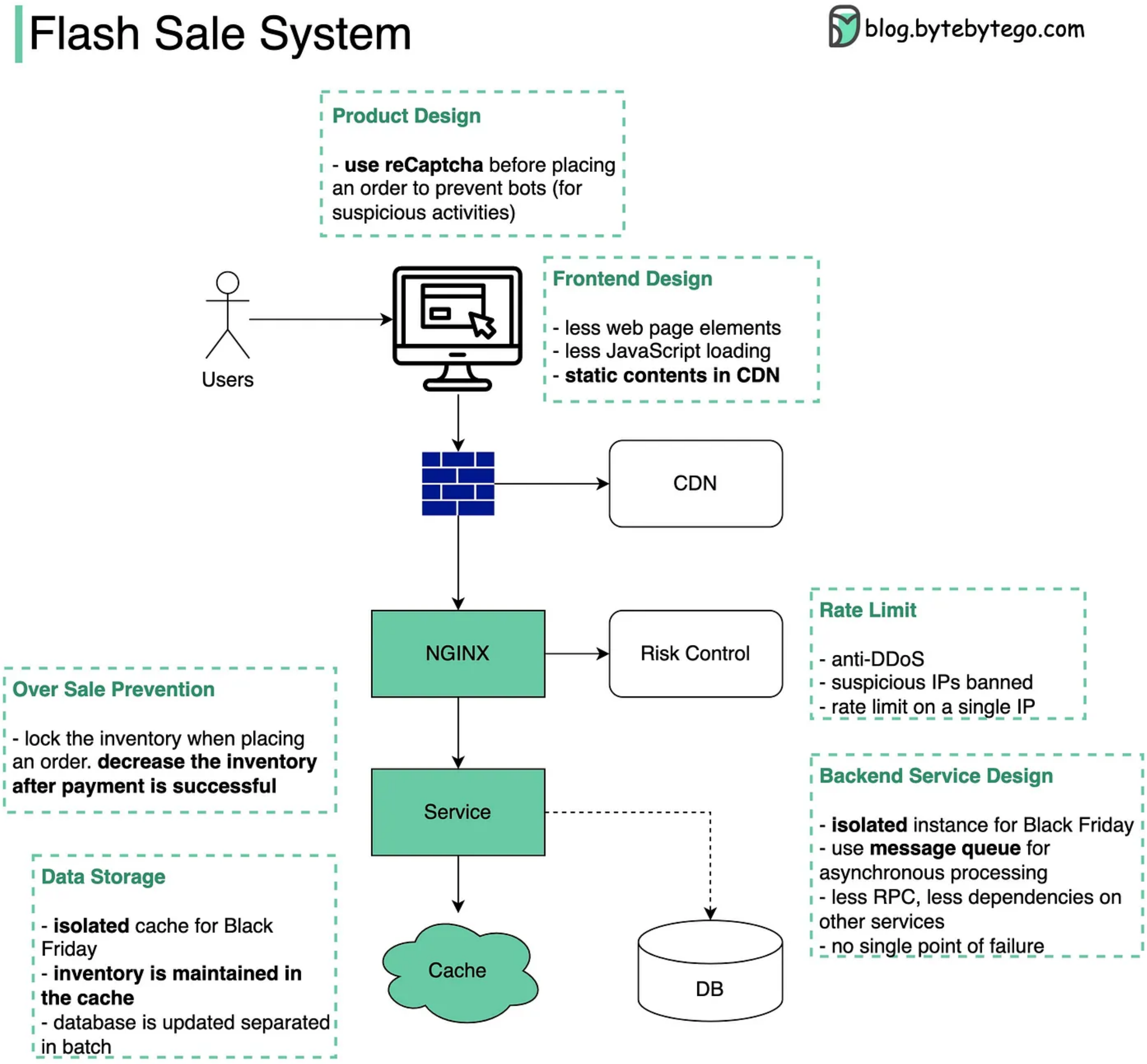
1. The consumer opens their digital wallet app to scan the QR code.
2. After confirming the amount is correct, the client clicks the “pay” button.
3. The digital wallet App notifies the PSP that the consumer has paid the given QR code.
4. The PSP payment gateway marks this QR code as paid and returns a success message to the consumer’s digital wallet App.
5. The PSP payment gateway notifies the merchant that the consumer has paid the given QR code.

Over to you: I have detailed how to pay using a dynamic QR code. It is dynamic because the QR code is dynamically generated each time. But sometimes, you could pay by scanning a printed QR code in a merchant’s shop, which is called the static QR code. Do you know how a static QR code works?

Flash sale system

Designing a system with extremely high concurrency, high availability, and quick responsiveness needs to consider many aspects **all the way from frontend to backend**.

See the diagram below for details:


Flash Sale System
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Product Design
- use reCaptcha before placing an order to prevent bots (for suspicious activities)
Users
Frontend Design
- less web page elements
- less JavaScript loading
- static contents in CDN
CDN
NGINX
Risk Control
Rate Limit
- anti-DDoS
- suspicious IPs banned
- rate limit on a single IP
Over Sale Prevention
- lock the inventory when placing an order. decrease the inventory after payment is successful
Service
Backend Service Design
- isolated instance for Black Friday
- use message queue for asynchronous processing
- less RPC, less dependencies on other services
- no single point of failure
Data Storage
- isolated cache for Black Friday
- inventory is maintained in the cache
- database is updated separated in batch
Cache
DB

Design principles:

1. Less is more. Fewer elements on the web page, fewer data queries to the database, fewer web requests, fewer system dependencies
2. Short critical path. Fewer hops among services or merge into one service
3. Async. Use message queues to handle high TPS
4. Isolation. Isolate static and dynamic contents, isolate processes and databases for rare items
5. Overselling is bad. When and how to manage the inventory is important

6. User experience is important. We don't want to inform users that they have successfully placed orders but later tell them no items are available

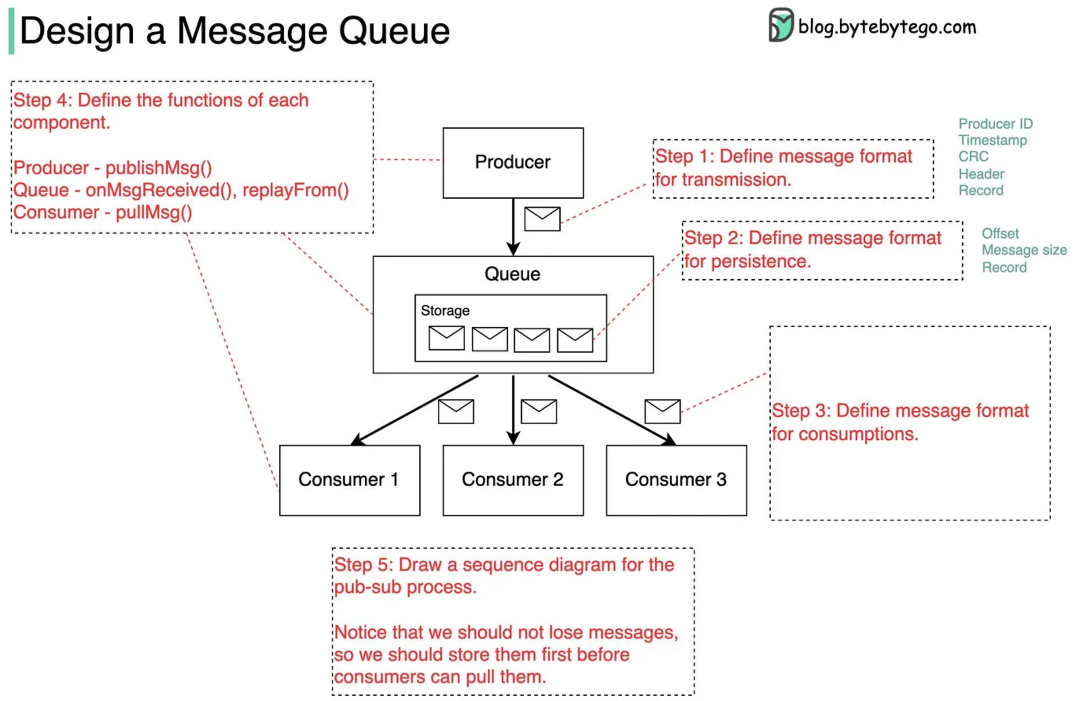
System design exercise

Let's try something different today.

Assuming in a system design interview, you are asked to design a distributed message queue. The following requirements are given:

1. Producers send messages to a message queue.
2. Consumers consume messages from a message queue.
3. Messages can be consumed repeatedly or only once.

The diagram below shows the naive design.


Design a Message Queue
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Step 4: Define the functions of each component.
Producer - publishMsg()
Queue - onMsgReceived(), replayFrom()
Consumer - pullMsg()
Producer
Step 1: Define message format for transmission.
Producer ID
Timestamp
CRC
Header
Record
Queue
Storage
Step 2: Define message format for persistence.
Offset
Message size
Record
Step 3: Define message format for consumptions.
Consumer 1
Consumer 2
Consumer 3
Step 5: Draw a sequence diagram for the pub-sub process.
Notice that we should not lose messages, so we should store them first before consumers can pull them.

- Is the design correct?
- Do you think the design satisfies all the requirements?
- If not, what else should be added?

Feel free to make your assumptions, comment with anything you think might be helpful, or post your design.

Other things we made:

Our bestselling book "System Design Interview - An Insider's Guide" is available in paperback and digital format.

Paperback edition: https://geni.us/XxCd

Digital edition: https://bit.ly/3lg41jK

New System Design YouTube channel: https://bit.ly/ByteByteGoVideos

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9 Comments

Write a comment...

lucashmsilva Jul 16, 2022 ♥ Liked by Alex Xu

Great content as always! Thanks a lot.

I'd like to add a thing or two about the settlement process with card networks. In step 4 of the Clearing and Settlement flow, networks such as Visa operate a bit differently in some regions.

For domestic transaction in Brazil, for example, the issuing banks have no direct contact at all with the acquiring banks.

Every day Visa sends the clearing files to the issuing banks, that must process and make the funds available. At the same time, it executes the settlement order through a clearing house.

In this process, Visa automatically calculates the fess and net values, then debits money from the issuers and credits the netted amount for the acquirers.

This is a special clearing operation only available for the card networks, regulated by the central bank and only available in a single clearing house.

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Rakibul Haq Jul 16, 2022

I pray that we never stop receiving such great learning contents from you.

LIKE (6) REPLY SHARE

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