

## Lesson 2: Digital Payments I – Fundamentals

### Module 1: Fintech and Innovation

Digital Finance Course

December 11, 2025

## What is a Payment?

- Transfer of monetary value from payer to payee
- Settlement of obligation or exchange
- Requires: Authorization, clearing, settlement
- Involves multiple intermediaries

## Payment Ecosystem Participants:

- Payer (consumer/business)
- Payee (merchant/recipient)
- Issuing bank (payer's bank)
- Acquiring bank (merchant's bank)
- Payment network (Visa, Mastercard)
- Payment processors (Stripe, Adyen)

## Key Payment Characteristics:

- Speed (real-time vs batch)
- Cost (fees and FX spread)
- Security (fraud prevention)
- Finality (irrevocable vs reversible)
- Reach (domestic vs cross-border)

## Payment Types:

- Push: Payer initiates (credit transfer)
- Pull: Payee initiates (direct debit)
- Card: Network-based (Visa/MC)
- A2A: Account-to-account (open banking)

---

Every payment involves authorization, clearing, and settlement across multiple intermediaries.

## 1. Authorization:

- Merchant requests payment approval
- Issuer checks funds/credit availability
- Response: Approve or decline
- Duration: 1-3 seconds
- Holds funds on card (authorization hold)

## 2. Authentication:

- Verify cardholder identity
- 3D Secure (3DS): Password/OTP
- Strong Customer Authentication (SCA, PSD2)
- Biometrics (fingerprint, face ID)
- Reduces fraud, increases approval rates

## 3. Clearing:

- Batch processing of transactions
- Exchange of transaction details
- Calculation of net positions
- Typically occurs daily (end-of-day)

## 4. Settlement:

- Actual movement of funds
- Issuer pays acquirer (via network)
- Merchant receives funds (minus fees)
- T+1 to T+3 for card payments
- Instant for real-time payment rails

---

Settlement is when funds actually move—clearing calculates who owes what.

# Card Payment Flow: Step-by-Step

## Transaction Steps:

- ① Customer presents card at merchant POS/online
- ② Merchant sends authorization request to acquirer
- ③ Acquirer routes to card network (Visa/MC)
- ④ Network routes to issuing bank
- ⑤ Issuer checks account and responds (approve/decline)
- ⑥ Response travels back through chain
- ⑦ Merchant receives approval, completes sale
- ⑧ Clearing batch sent at end of day
- ⑨ Settlement occurs (funds transferred)
- ⑩ Merchant receives payment (T+1 to T+3)

## Messaging Standards:

- ISO 8583: Card transaction messaging
- EMV: Chip card standards
- 3D Secure: Online authentication protocol
- PCI DSS: Security standards for card data

## Approval Rate Factors:

- Sufficient funds/credit limit
- Card not blocked/expired
- Fraud screening passed
- Correct CVV and address
- Industry average: 85%-90%

---

Card authorization takes 1-3 seconds; merchants wait 1-3 days for settlement.

## Visa Inc:

- Founded: 1958 (BankAmericard)
- Market cap: \$530B (2024)
- Cards in circulation: 4.2B globally
- Transaction volume: \$14.8 trillion (2023)
- Revenue: \$32.7B (FY2023)
- Net margin: 51%

## Mastercard Inc:

- Founded: 1966 (Interbank Card)
- Market cap: \$410B (2024)
- Cards in circulation: 3.1B globally
- Transaction volume: \$9.0 trillion (2023)
- Revenue: \$25.1B (FY2023)
- Net margin: 46%

## Business Model:

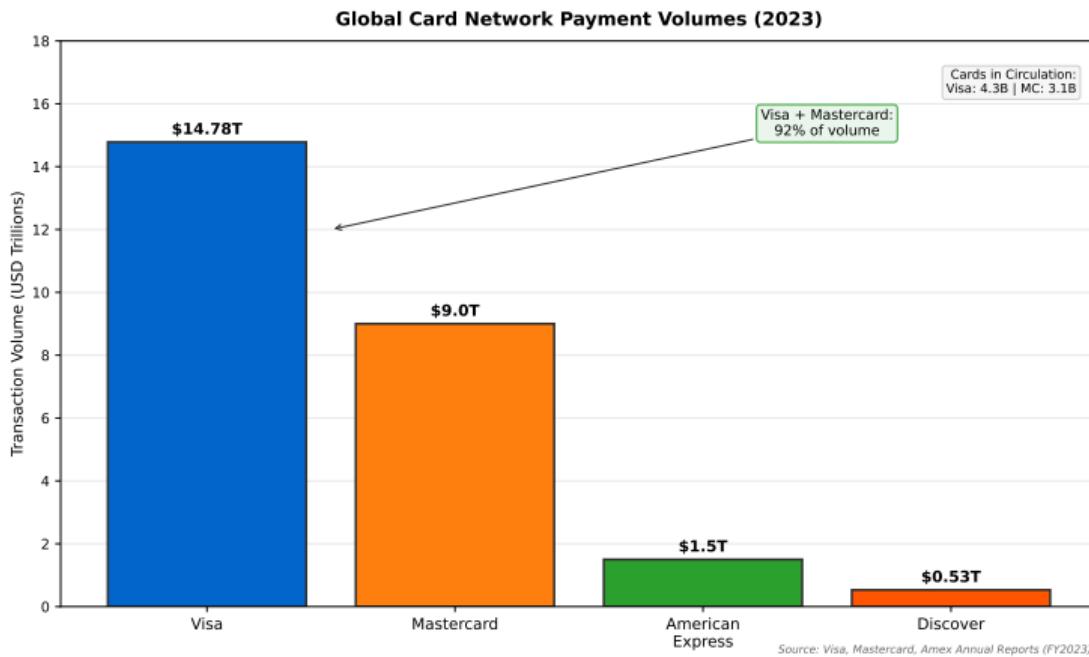
- Four-party scheme (issuer, acquirer, network, cardholder)
- Do NOT issue cards or acquire merchants
- Revenue from transaction fees
- License brand to financial institutions
- Operate global payment networks

## Revenue Streams:

- Service fees: 0.13%-0.15% per transaction
- Cross-border assessment fees: 1.0%-1.1%
- Volume-based rebates and incentives
- Value-added services (fraud, analytics)
- Licensing and certification

Visa and Mastercard are technology networks, not card issuers—they license the brand.

# Card Network Payment Volumes (2023)



Visa + Mastercard process 92% of global card volume; four-party model creates network effects.

## What is Interchange?

- Fee paid by acquirer to issuer
- Compensation for fraud risk, funding, processing
- Set by card networks (Visa, Mastercard)
- Largest component of merchant fees
- Controversial and heavily regulated

## Interchange Rate Factors:

- Card type (debit vs credit, premium)
- Merchant category code (MCC)
- Transaction type (card-present vs online)
- Region (EU capped, US market-driven)
- Card acceptance method (chip vs swipe)

## Typical Interchange Rates (EU):

- Consumer debit: 0.2% (capped by regulation)
- Consumer credit: 0.3% (capped by regulation)
- Commercial cards: Uncapped (1.5%-2.5%)
- Cross-border: Additional 0.4%-0.8%

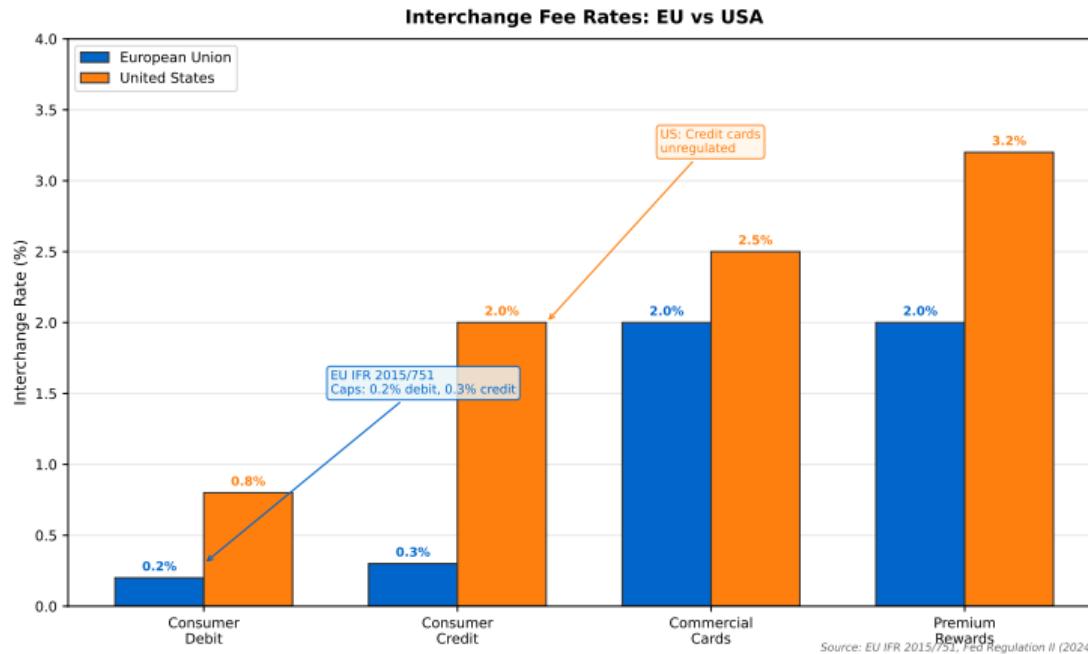
## Typical Rates (USA, unregulated):

- Debit card: 1.0%-1.5%
- Credit card: 1.5%-3.0%
- Premium rewards cards: 2.5%-3.5%
- Example: \$100 purchase = \$2-\$3 interchange

---

Interchange is the largest component of merchant fees—funding bank rewards programs.

# Interchange Fee Rates: EU vs USA



EU regulation caps consumer interchange at 0.2-0.3%; US credit cards remain unregulated.

# Merchant Discount Rate (MDR): Total Cost

## MDR Components:

- Interchange fee (70%-80% of MDR)
- Card network fee (0.13%-0.15%)
- Acquirer markup (0.10%-0.50%)
- Payment processor fee (if applicable)

## Total MDR Examples (EU):

- Debit card: 0.5%-1.0%
- Credit card: 0.8%-1.5%
- American Express: 2.0%-3.5% (three-party)
- Large merchants: Negotiate lower rates
- Small merchants: Pay higher rates

## Merchant Cost Analysis:

- €100 credit card purchase (EU)
- Interchange: €0.30 (0.3% cap)
- Network fee: €0.14 (0.14%)
- Acquirer margin: €0.25 (0.25%)
- Total MDR: €0.69 (0.69%)
- Merchant receives: €99.31

## Impact on Business:

- Low-margin sectors (supermarkets: 2%-3%)
- Payment fees = significant cost
- Incentive for cash or A2A payments
- Volume discounts for large merchants

---

Low-margin retailers (supermarkets: 2-3% margin) see payment fees as significant costs.

## European Union (IFR 2015):

- Consumer debit cap: 0.2%
- Consumer credit cap: 0.3%
- Commercial cards: Exempt
- Cross-border treated as domestic
- Saved merchants €1.2B annually

## United Kingdom (Post-Brexit):

- Maintained EU caps for domestic
- Cross-border EEA: Caps removed (2021)
- Interchange tripled on EU cards (1.5%)
- PSR reviewing commercial card fees

## United States:

- Durbin Amendment (2010): Debit cap \$0.21 + 0.05%
- Applies only to large banks (\$10B+ assets)
- Credit cards: Unregulated
- Ongoing litigation (merchant class actions)

## Australia:

- RBA regulation since 2003
- Weighted average caps
- Credit: 0.5%, Debit: 0.2% (2017)
- Allowed surcharging (pass cost to consumer)

---

EU IFR 2015 saved merchants EUR 1.2B annually; post-Brexit UK saw interchange triple on EU cards.

## What is ACH?

- Electronic batch payment system (US)
- Operated by Nacha (formerly NACHA)
- Bank-to-bank transfers
- Low cost, high volume, batch processing
- 31B transactions, \$76 trillion (2023)

## ACH Transaction Types:

- Direct deposit (payroll, benefits)
- Direct debit (bill payments, subscriptions)
- B2B payments (vendor payments)
- P2P transfers (Venmo, Cash App backend)
- Tax payments and refunds

## ACH Processing:

- Batch processing (4 times daily)
- Standard: T+1 settlement
- Same-Day ACH: Settlement same day (since 2016)
- Cost: \$0.20-\$1.50 per transaction
- Pull (debit) or Push (credit)

## ACH vs Wire Transfer:

- ACH: Batch, low cost, T+1, reversible
- Wire: Real-time, high cost (\$15-\$30), irrevocable
- ACH volume: 100x higher than wire
- Wires for large/urgent payments

---

ACH processes 31B transactions/year at \$0.20-\$1.50 each—100x cheaper than wire transfers.

## What is SEPA?

- Harmonized euro payment system
- Covers 36 countries (EU + EEA + others)
- Launched: 2008 (credit transfer), 2009 (direct debit)
- Treats cross-border like domestic
- 500M+ citizens, 20M+ businesses

## SEPA Instruments:

- SEPA Credit Transfer (SCT): Push payments
- SEPA Instant Credit Transfer (SCT Inst): Real-time
- SEPA Direct Debit (SDD): Pull payments
- SEPA Card Framework (less successful)

## SEPA Credit Transfer (SCT):

- Settlement: T+1 (next business day)
- No amount limit
- IBAN and BIC required
- ISO 20022 XML messaging
- Cost: Same as domestic

## SEPA Instant (SCT Inst):

- Launched: November 2017
- Settlement: 10 seconds maximum
- Limit: €100,000 per transaction (raised from €15k in 2024)
- Available 24/7/365
- Adoption: 70%+ of EU banks (2024)
- Mandatory for banks by 2025 (EU regulation)

---

SEPA Instant settles in 10 seconds, 24/7/365—mandatory for all EU banks by 2025.

## SDD Core Scheme:

- Consumer pull payments
- Requires signed mandate
- Pre-notification required (14 days default)
- Refund rights: 8 weeks (authorized), 13 months (unauthorized)
- Settlement: T+1 or T+2

## SDD B2B Scheme:

- Business-to-business only
- No refund right (authorized mandate)
- Bank verification of mandate
- Lower fraud risk
- Separate scheme identifier

## Mandate Requirements:

- Unique Mandate Reference (UMR)
- Creditor Identifier (CI)
- Debtor IBAN
- Debtor signature (physical or electronic)
- Electronic mandates: PSD2 SCA required

## Use Cases:

- Recurring bills (utilities, telecom)
- Subscriptions (streaming, gym)
- Loan repayments
- Insurance premiums
- Variable amount collections

---

Direct debit mandates allow 8-week refunds (Core) or no refunds (B2B)—know your scheme.

## Frontend Processors:

- Gateway providers (Stripe, Adyen, Checkout.com)
- Authorization routing
- Fraud screening
- 3D Secure authentication
- Merchant dashboard and APIs
- Revenue: Payment processing fees

## Backend Processors:

- Clearing and settlement
- Reconciliation services
- Chargeback handling
- FIS, Fiserv, TSYS (now Fiserv)

## Acquirer vs Gateway:

- Acquirer: Licensed bank, holds funds, settles
- Gateway: Technology layer, routes transactions
- Full-stack processors: Combine both (Adyen, Stripe)
- Traditional: Separate acquirer + gateway

## Modern Payment Stack:

- Merchant integration: API/SDK
- Payment orchestration: Routing logic
- Multiple acquirers: Redundancy, optimization
- Network tokens: Enhanced security
- Real-time reporting: Analytics

---

Full-stack processors (Adyen, Stripe) combine gateway and acquiring—simplifying integration.

# Payment Service Providers (PSPs)

## Leading PSPs:

- Stripe: \$1 trillion TPV (2023), 100+ countries
- Adyen: €786B TPV (2023), unified platform
- PayPal/Braintree: \$1.5 trillion TPV (2023)
- Worldpay (FIS): \$2.2 trillion TPV
- Square/Block: \$211B TPV (2023)

## PSP Value Proposition:

- Single API for multiple payment methods
- Global reach with local acquiring
- Fraud prevention tools
- PCI compliance management
- Fast onboarding (hours vs months)

## Pricing Models:

- Blended rate: e.g., 2.9% + \$0.30 per transaction
- Interchange plus: IC + 0.5% + \$0.10
- Custom enterprise pricing (volume discounts)
- Monthly subscription fees (optional)

## Feature Comparison:

- Stripe: Developer-first, excellent APIs
- Adyen: Enterprise focus, single platform
- PayPal: Consumer brand, checkout conversion
- Square: SMB focus, integrated POS
- Checkout.com: High customization, flexible

---

Stripe pioneered developer-first APIs—onboarding in hours vs months with traditional acquirers.

## PCI DSS Overview:

- Payment Card Industry Data Security Standard
- Managed by PCI Security Standards Council
- Mandatory for all card payment entities
- Current version: PCI DSS 4.0 (March 2022)
- Compliance deadline: March 2025

## 12 Requirements (6 Goals):

- ① Build and maintain secure network
- ② Protect cardholder data
- ③ Maintain vulnerability management
- ④ Implement strong access controls
- ⑤ Monitor and test networks
- ⑥ Maintain information security policy

## Compliance Levels (Visa):

- Level 1: 6M+ transactions/year (annual audit)
- Level 2: 1M-6M transactions (annual SAQ)
- Level 3: 20k-1M e-commerce (annual SAQ)
- Level 4: <20k e-commerce (annual SAQ)

## Key Technical Controls:

- Encryption of cardholder data
- Tokenization (replace PAN with token)
- Firewall and network segmentation
- Vulnerability scanning
- Penetration testing
- Log monitoring and SIEM

---

PCI DSS 4.0 deadline is March 2025—12 requirements, 6 goals, mandatory for all card processors.

## Fraud Types:

- Card-not-present (CNP): Online fraud
- Card-present: Counterfeit, stolen cards
- Account takeover (ATO): Credential theft
- Friendly fraud: Chargeback abuse
- Refund fraud: Return scams

## Fraud Statistics (Global):

- Total card fraud: \$32B annually (2023)
- CNP fraud: 75% of total fraud
- Fraud rate: 0.15%-0.20% of volume
- Chargebacks: 0.6%-1.0% of transactions
- Cost to merchants: 3.6x transaction value

## Prevention Technologies:

- 3D Secure 2.0: Frictionless authentication
- Machine learning fraud scoring
- Device fingerprinting
- Behavioral biometrics
- Address Verification System (AVS)
- CVV/CVC verification

## Liability Shift:

- EMV chip: Shift to non-compliant party
- 3DS: Shift to issuer (if authenticated)
- Merchants incentivized to adopt
- Reduces fraud and chargebacks

---

Card fraud costs \$32B annually; 3D Secure 2.0 shifts liability to issuers on authenticated transactions.

## Chargeback Reasons:

- Fraud: Card used without authorization
- Processing error: Duplicate charge, wrong amount
- Consumer dispute: Product not received/as described
- Authorization issue: Expired authorization

## Chargeback Process:

- ① Cardholder disputes with issuer (120 days)
- ② Issuer initiates chargeback
- ③ Merchant notified via acquirer
- ④ Merchant provides evidence (10-45 days)
- ⑤ Issuer reviews and decides
- ⑥ Pre-arbitration or arbitration (if disputed)
- ⑦ Final decision (issuer or network)

Chargeback ratio  $\geq 0.9\%$  triggers Visa monitoring program—\$20-\$100 fee per dispute.

## Merchant Impact:

- Chargeback fee: \$20-\$100 per case
- Lost revenue from sale
- Lost merchandise (if shipped)
- Administrative time
- High ratios: Monitoring programs

## Excessive Chargeback Programs:

- Visa:  $\geq 0.9\%$  ratio or 100/month
- Mastercard:  $\geq 1.5\%$  ratio or 100/month
- Penalties: Fines, higher MDR, termination
- Prevention: Fraud tools, clear policies

## Key Characteristics:

- Settlement in seconds ( $<10$  seconds)
- 24/7/365 availability
- Immediate funds availability
- Irrevocable payment
- ISO 20022 messaging standard

## Global RTP Systems:

- UK: Faster Payments Service (2008)
- India: UPI (2016, 12B txns/month)
- Brazil: PIX (2020, 3.6B txns/month)
- USA: FedNow (2023), RTP Network (2017)
- EU: SEPA Instant (2017)
- China: Alipay/WeChat (proprietary)

## UPI Success (India):

- Volume: 12.8B transactions/month (Oct 2024)
- Value: \$240B/month
- Zero transaction fees (government subsidy)
- QR code-based payments
- 500M+ active users

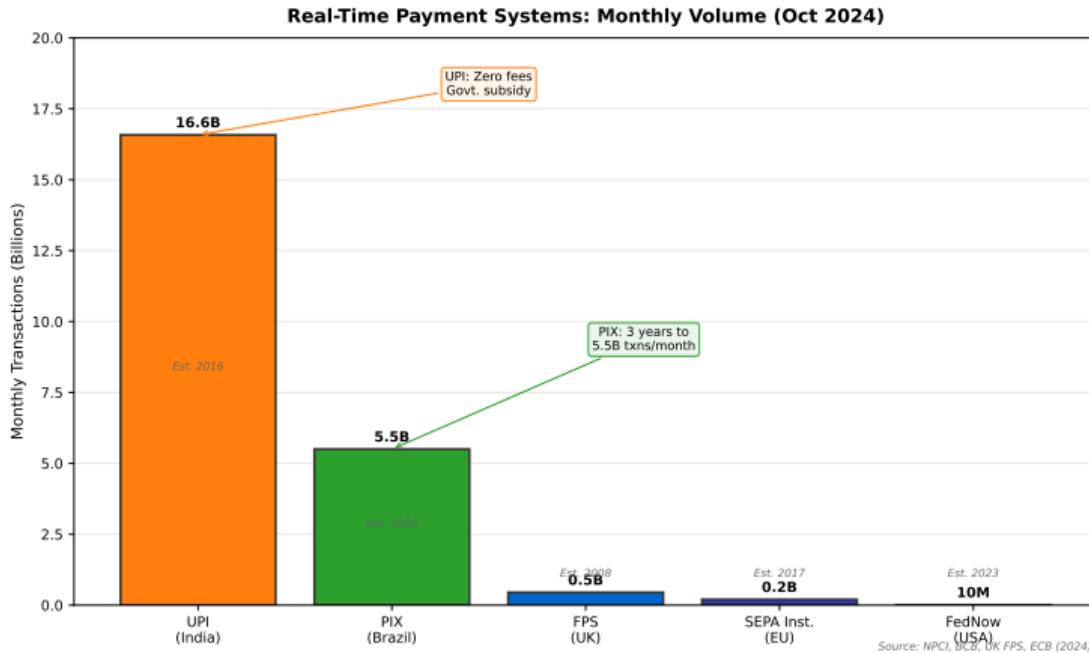
## Benefits:

- Improved cash flow
- Reduced fraud (account verified)
- Lower cost than cards
- Enhanced customer experience
- Financial inclusion (no card needed)

---

India's UPI processes **16.58B transactions/month** at zero fees—government-subsidized success story.

# Real-Time Payment Systems: Global Adoption



UPI and PIX demonstrate RTP potential: 16.58B and 5.5B monthly transactions respectively.

## FedNow Service:

- Launched: July 2023
- Operated by Federal Reserve
- Competing with RTP Network (Clearing House)
- Instant settlement (seconds)
- No transaction amount limit (initially \$500k)
- Available to all US depository institutions

## Adoption Challenges:

- Requires bank system upgrades
- Competition from existing RTP
- Zelle dominance in P2P
- Limited initial use cases
- 700+ financial institutions signed up (2024)

## RTP Network (Clearing House):

- Launched: 2017
- Private sector alternative
- Owned by 22 major banks
- 400+ participants
- Similar functionality to FedNow

## Use Cases:

- Emergency disbursements (disaster relief)
- Instant refunds and rebates
- Just-in-time payroll
- Gig economy payments
- Bill pay with immediate credit
- Business liquidity management

---

FedNow launched July 2023—competes with private RTP Network for US real-time dominance.

## Cards:

- Speed: 2-4 seconds authorization, T+1-3 settlement
- Cost: 1%-3% MDR
- Reach: Global
- Security: Strong (EMV, 3DS)
- Consumer protection: Chargebacks
- Best for: E-commerce, POS

## ACH/SEPA:

- Speed: T+1 (standard), same-day available
- Cost: \$0.20-\$1.50 or 0.2%-0.5%
- Reach: Domestic/regional
- Security: Bank-level
- Best for: Recurring, B2B, large amounts

## Real-Time Payments:

- Speed: <10 seconds
- Cost: Low (often free to consumer)
- Reach: Domestic
- Security: Bank-verified accounts
- Irrevocable: Limited consumer protection
- Best for: P2P, urgent payments

## Wire Transfer:

- Speed: Same-day
- Cost: \$15-\$50 per transaction
- Reach: Global (SWIFT)
- Security: High, irrevocable
- Best for: Large, urgent, cross-border

---

Choose payment method based on trade-offs: speed vs cost vs security vs consumer protection.

## Payment Lifecycle:

- Authorization → Authentication → Clearing → Settlement
- Multiple intermediaries (issuer, acquirer, network)
- Card payments: 2-3 days for merchant settlement
- Real-time rails: Seconds

## Card Networks:

- Visa and Mastercard dominate globally
- Four-party model (efficient network effects)
- Interchange = largest merchant cost component
- EU regulation caps interchange (0.2%-0.3%)

## Payment Systems:

- ACH: US batch system, low cost, T+1
- SEPA: EU harmonized system, instant available
- Real-time: Growing globally, instant settlement
- Trade-offs: Speed vs cost vs security

## Emerging Trends:

- Real-time payment adoption accelerating
- Account-to-account (A2A) challenging cards
- ISO 20022 standardization
- Open banking enabling payment initiation

---

Real-time A2A payments are disrupting cards—lower cost, instant settlement, no intermediaries.

## Lesson 3: Digital Payments II – Mobile Wallets

We will explore:

- NFC technology and contactless payments
- Tokenization and security
- Apple Pay, Google Pay architecture
- M-Pesa and mobile money in emerging markets
- Alipay, WeChat Pay, and super-app models